Evaluation of The Use of De-Oiled Sunflower Meal Protein Powder in Mini Frankfurter-Type Chicken Sausage

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Abstract

This research aimed to evaluate the effect of the protein powder (SPP) obtained from de-oiled sunflower meal, a by-product of sunflower oil extraction, on the physicochemical, textural, and sensory properties of mini frankfurter-type chicken sausage. The extracted proteins from the sunflower meal were added to the sausage formulation at 1% concentration, and the SPP-added sausage sample was compared with the control sample. The incorporation of SPP increased hardness, chewiness, and cohesiveness properties compared to the control sausages and slightly improved sensory attributes. The results suggest that SPP may serve as a promising ingredient to improve the quality parameters of emulsified meat products.

Keywords: Protein powder, sunflower meal, by-product valorisation, chicken sausage

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INTRODUCTION

Due to the modern lifestyle, more people consume processed meat products such as beef or chicken sausages. In addition, customers favor consuming products with enhanced sensory, nutritional, and health attributes while having minimal effect on the environment (Ghafouri-Oskuei et al., 2020). Plant proteins have been gaining attention due to the drawbacks resulting from production of animal proteins (i.e., depletion of environmental resources) (Ermis et al., 2023; Wang et al., 2023). Plant proteins' technological properties and nutritional benefits may improve the textural and nutritional properties of emulsified meat products such as sausages.

After palm, soybean, and rapeseed, sunflower is the fourth crop in the world used to produce oil (Grasso et al., 2020). Sunflower meal, the remaining part (up to 36% of the seed) after extracting oil, has the potential to be consumed by humans (Salgado et al., 2012) while being primarily utilized as animal feed (Anal, 2017). Due to low amounts of antinutritive compounds, high protein content (around 35%), and no toxic substances found in de-oiled sunflower meal, it can be utilized as a promising source of proteins (de Oliveira Filho and Egea, 2021; Kaur and Ghoshal, 2022).

Previous studies report that sunflower proteins have comparable or superior emulsifying characteristics to egg powder, soy proteins, skim milk powder, and can form stable emulsions (González-Pérez and Vereijken, 2007; Shchekoldina and Aider, 2012; Pickardt et al., 2015). The spray drying technique is known as inexpensive and available in continuous and industrial production. Drying into powder preserves the nutritional, physicochemical, and organoleptic properties of proteins as well as improves the shelf life (Amagliani et al., 2016; Ermiş and Karasu, 2020; Khanji et al., 2018). Previous studies have reported the use of several plant-based ingredients, such as cold-pressed hazelnut cake (Atalar et al., 2023), flaxseed and tomato powders (Ghafouri-Oskuei et al., 2020), and sunflower seed flour (Grasso et al., 2020) in sausage products. However, to our knowledge, no study in the literature has reported the effects of spray-dried sunflower meal protein (SPP) in frankfurter-type chicken sausage formulation.

The objective of this study was to investigate the effect of SPP on the physicochemical characteristics and sensory attributes of mini frankfurter-type chicken sausage.

MATERIAL and METHOD

Materials

The ingredients to produce sausage samples were provided by a chicken meat processing company (CP Food, Türkiye). The chemicals were obtained from a local distributor of Sigma Aldrich (Taufkirchen, Germany). All chemicals and reagents were of analytical reagent grade.

Methods

SPP production and characterization

In our previous study, we extracted the proteins from sunflower meal and produced protein powder using a pilot-scale spray dryer. The method used to obtain SPP is detailed in our previous publication (Ermiş & Karasu, 2020). The production steps are outlined in Fig. 1. The methods used for the characterization of SPP were also reported by Ermiş & Karasu (2020) previously.

Several analyses were conducted to evaluate flowability using Hausner Ratio and Angle of Repose approaches, chemical functional groups using FTIR, thermal properties using DSC, emulsion activity index (EAI), emulsion stability index (ESI), solubility, and wettability. In addition, SEM images were obtained to analyze the microstructure of the SPP particles. The analyses conducted for SPP characterization, including the methodologies and instrumentation employed, along with the experimental data obtained, are comprehensively detailed in our previously published paper (Ermiş and Karasu, 2020). These data are not reiterated in the present study to avoid redundancy.

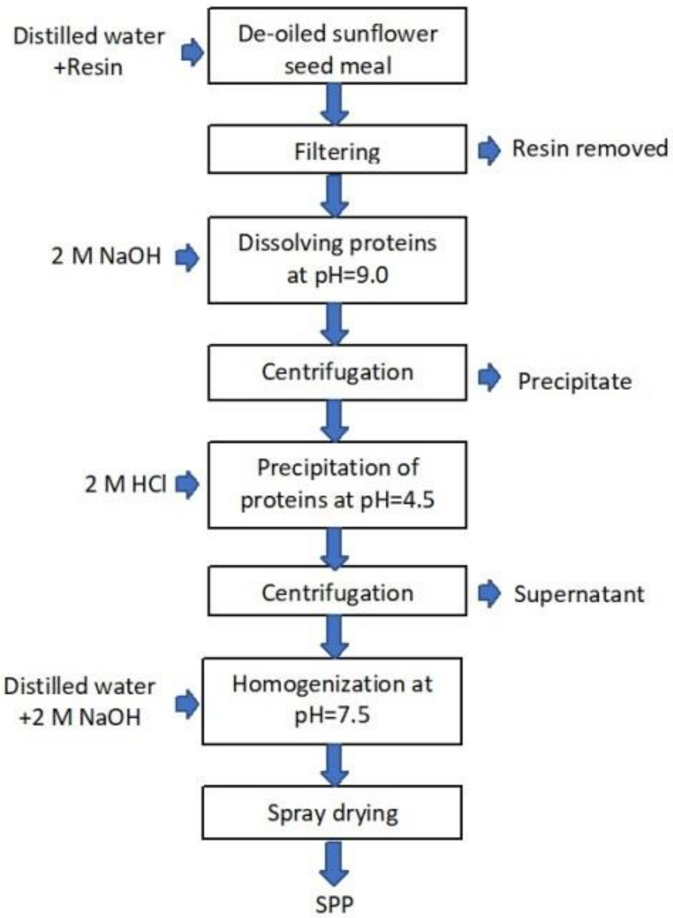

Figure 1. Protein powder production steps

Preparation of sausage samples

Frankfurter-type mini chicken sausage samples were prepared according to the method described by Peña-Saldarriaga et al. (2020) with modifications. The ingredients utilized comprised chicken breast meat, ice, water, spice mixture, wheat flour, starch, salt, sodium acetate, sodium nitrite, sodium polyphosphate, sodium ascorbate, carmine, and celery powder. 1% SPP (w/w) was added to the formulation to evaluate the effect of SPP on some quality attributes of sausage samples. 1% concentration was suggested by Atalar et al. (2023) to get optimized emulsion quality and stability. A control sample without SPP was also produced for comparison. The sausage samples were cooked for 90 min at 75–80 °C and kept at room temperature in closed plastic containers to reduce the heat of the samples before placing them into a refrigerator. They kept at around 4 °C until conducting the analyses.

Proximate analysis

Chemical contents were analyzed using AOAC standard methods (AOAC, 2000). Kjeldahl method and Soxhlet method were employed to analyze the protein and lipid contents, respectively. The pH was directly measured using a potentiometer (Hanna HI 2211), calibrated with pH buffer solutions of 4.0 and 7.0 at 25 °C. Sodium chloride content was analyzed according to ISO 1841-2 (1996).

Color measurement

A colorimeter (Konica Minolta, CR400, Japan) was employed to determine the instrumental color properties of sausage samples. The CIELAB space parameters given as lightness (L*), redness-greenness (a*), and yellowness-blueness (b*) were measured (Joint ISO/CIE Standard, 2019).

Textural Analysis

The textural properties of sausage samples were evaluated as described by Peña-Saldarriaga et al. (2020). Samples were sectioned into 20 mm cubic portions. The textural properties of each sample were assessed using a cylinder probe (35 mm diameter) attached to a Texture Analyzer (TA-XT2, Stable Micro System Ltd., Surrey, UK). Hardness, cohesiveness, springiness, and chewiness were determined.

Sensory analysis

Ten trained panelists took part in conducting the sensory test. The assessment used a 5-point hedonic scale (Ghafouri-Oskuei et al., 2020). Samples were cooked in a microwave for 15 s using thin slices 2-3 cm long. The sausage samples having no SPP and having 1% SPP were compared to one another. The panelists evaluated selected sensory attributes (texture, color, taste, and overall acceptability). They received water and unsalted crackers in between each sample's examination.

Statistical analysis

The mean and standard deviation values were calculated using the data obtained from the experiments performed in triplicate, where possible. The data was subjected to one-way analysis of variance (ANOVA) using Minitab 17 software, and mean was compared using Tukey's difference test at $p<0.05$.

RESULTS and DISCUSSION

Chemical, thermal and techno-functional properties of SPP

The optimized spray-drying conditions were applied by Ermiş & Karasu (2020) to produce spray-dried sunflower meal protein powder (SPP), and 30% of total proteins could be extracted and precipitated from the de-oiled sunflower meal. The techno-functional properties of SPP, such as flowability, compressibility, solubility, oil binding capacity, and emulsifying capabilities, are essential parameters that need to be investigated to design food processing and to develop new food productss (Shokri et al., 2022). Oil binding capacity (OBC) affects the techno-functional properties and taste of food products (Pickardt et al., 2015). It is necessary to ascertain and assess protein solubility because it is a significant phenomenon in terms of functional and technological features such as emulsifying and foaming capabilities (González-Pérez and Vereijken, 2007; Saeed and Cheryan, 1988). The proteins' solubility is affected by pH, and the lowest solubility was recorded at about pH 4.0 (Karayannidou et al., 2007). The surface hydrophobicity and net charge of peptides can also affect solubility (Sila et al., 2014). Wettability is also controlled by contact angles, the size of the pores between the particles, and the size of the pores themselves.

The solubility, wettability, oil binding capacity (OBC), emulsion activity index (EAI) and emulsion stability index (ESI) values were reported by Ermiş & Karasu (2020) as 3.75% at 21±2 °C at a pH of 7.0, 0.390 g water, 2.85 mLg-1, 74.70 m^2g^{-1} and 5.25%, respectively. In addition, the bulk (poured) density (ρb), tapped density (ρt), Hausner ratio (ρt/ρb), and Angle of Repose values were reported as 403 $kg.m^{-3}$, 639 $kg.m^{-3}$, 1.58 and 50º, respectively.

The OBC, EAI and ESI values of SPP are lower when compared to soy protein isolate which was studied by Zhang and Zhao (2013). Poor wettability and dispersibility are attributed to the high protein content in powders (Ji et al., 2015). The solubility of SPP in water was reported as lower when compared with the data previously reported by Pickardt et al. (2015). On the other hand, Ji et al. (2015) reported the wettability of milk protein isolate having 86% protein as 0.236 g water, which is lower than the wettability of SPP. The difference might be linked to the type of proteins, the varied sizes of protein particles, their surface characteristics, and the spaces between them. The data obtained from flowability analyses indicate cohesive attribute, and hence, poor flow behavior of SPP (Ermis et al., 2018). SEM images were used to analyze the shape and surface characteristics of protein particles (Fig. 2).

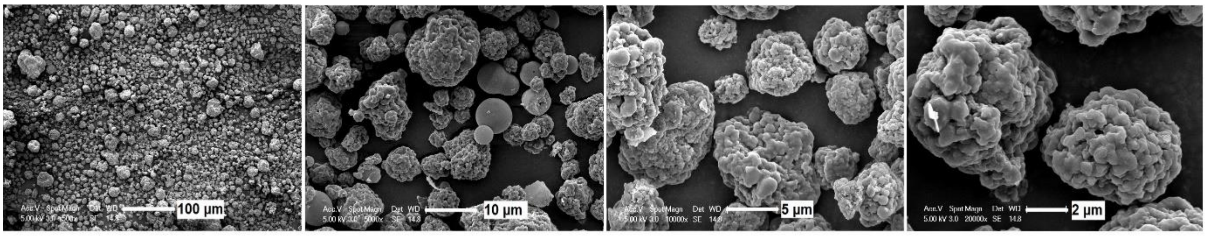

Figure 2. SEM images of SPP particles

The images exhibit different fractions of particles of different sizes. The particles possessed uneven and wrinkled surface characteristics, as seen in Fig. 2. Similar characteristics of rice protein concentrate particles were reported by Amagliani et al. (2016). Additionally, they state that spray-dried protein powders typically have particle characteristics, including uneven, cracked, hollow, wrinkled, and porous appearances.

Chemical composition and color properties of sausage samples

Table 1 displays the chemical composition of sausage samples. By adding SPP to the sausage formulation, an increase in crude protein and ash contents was noticed while fat and salt concentarions were decreased. However, no difference was observed in moisture content as a result of the addition of SPP. Ghafouri-Oskuei et al. (2020) added tomato and flaxseed powders to sausage, and they observed an increase in dry matter, protein, carbohydrate, ash, and fiber content while they reported a decrease in moisture content. Ozturk-Kerimoglu et al. (2022) report that fortification of sausage with whey protein powder resulted in an increased amount of protein. The images of SPP-added sausage sample can be seen in Fig. 3.

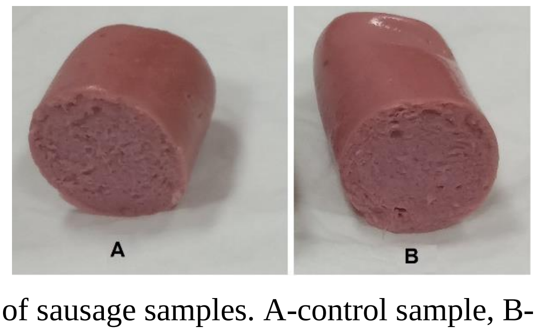

Figure 3. Images of sausage samples. A-control sample, B-SPP-added sample

The effect of SPP incorporation into chicken sausage formulation on the final product's color was evaluated. The instrumental color (L*, a*, and b*) of the sausage samples are given in Table 1. As it can be seen in the data outlined in Table 1, the protein fortification led to a slight change in color properties. The L* and a* values were decreased as a result of adding 1% SPP, while the b* value was increased by around one unit compared to the control sample. It was found that the findings of Broucke et al. (2022)) and Trindade et al. (2023) resonate with the findings of this study. Ozturk-Kerimoglu et al. (2022) found that a* and b* values were higher in whey protein-added sausage samples, while no changes were seen in the L* value. In another study, higher b* and slightly lower L* values for the samples containing soy protein were reported (Velemir et al., 2020).

Table 1. Proximate composition of sausage samples

Composition (%)	Sausage (Control)	SPP-added Sausage
Crude protein	13,69± 0.09b	14,32± 0.12a
Fat	14,29± 0.14a	13,08± 0.07b
Moisture	67,24± 0.32a	67,56± 0.21a
Salt	2,67± 0.21a	2,61± 0.19a
pH	6,24± 0.11a	6,26± 0.21a
Ash	2.2 ± 0.04b	2.4 ± 0.03a
L*	62.9 ± 0.25a	61.2 ± 0.30b
a*	28.3 ± 0.89a	27.5 ± 0.91b
b*	10.98 ± 0.66b	11.8 ± 0.58a

L* represents lightness, ranging from 0 (black) to 100 (white); a* denotes the green (negative)–red (positive) coordinate; and b* indicates the blue (negative)– yellow (positive) coordinate. Different letters within the same row depict significant differences ($p<0.05$)

Sensory evaluation results

Texture, color, taste, and overall acceptance attributes of the sausage sample containing SSP were assessed by ten trained panelists in comparison to a control sample (Table 2). It can be seen in the table that the taste, texture, color, and overall acceptance attributes of SSP-added sample had slightly higher scores compared to the control sample ($p<0.05$). Similar results were reported by Zouari et al. (2012). Their findings revealed that adding whey powder improved the sensory properties of low-fat sausage, such as flavor, firmness, and sliceability. Eyiler and Oztan (2011) observed more appetizing Frankfurter-type sausages after adding tomato powder. On the other hand, they report a decrease in the scores of flavor, odor, or overall acceptance of flaxseed powder-added sample. Similar findings are reported by Ghafouri-Oskuei et al. (2020) claiming a decrease in the general acceptance of sausage samples fortified with flaxseed powder.

Table 2. Sensory analysis scores of sausage samples

Sample	**Texture**	**Color**	**Taste**	**Overall acceptability**
Sausage (Control)	3.8 ± 0.31b	3.7 ± 0.95a	3.6 ± 0.58b	3.6 ± 0.43b
SPP-added Sausage	4.2 ± 0.73a	3.8 ± 0.56a	3.8 ± 0.49a	3.8 ± 0.22a

Different letters within the same column depict significant differences ($p<0.05$)

Textural evaluation results

The textural properties of SSP-added sausage are outlined in Table 3 compared to the control sample. The result showed a slight increase in hardness, chewiness, and cohesiveness values compared to the control sample ($p<0.05$). However, no significant change was obtained from the springiness value.

In agreement with this study's findings, fortifying chicken sausage with soy protein powder and soy protein isolate led to an increase in hardness and a firmer product (Pagthinathan and Gunasekara, 2021; Velemir et al., 2020). Similarly, adding whey powder to a low-fat sausage formulation enhanced the hardness, chewiness, and gel stress (Zouari et al., 2012). Contrary to the findings in this study, Ozturk-Kerimoglu et al. (2022) report reduced adhesiveness, chewiness, and hardness of microparticulated whey protein-added sausages.

Table 3. Textural properties of sausage samples.

Parameter	Sausage (Control)	SPP-added Sausage
Hardness (N)	17.26 ± 0.61b	19.70 ± 0.72a
Chewiness (N)	10.25 ± 0.53b	12.08 ± 0.56a
Springiness	0.97 ± 0.11a	0.97 ± 0.17a
Cohesiveness	0.82 ± 0.09b	0.83 ± 0.16a

Different letters within the same row depict significant differences ($p<0.05$)

CONCLUSION

Proteins from de-oiled sunflower meal were extracted and powdered using a pilot scale spray dryer and added into a mini frankfurter-type chicken sausage formulation. The SPP's functional, microstructural, and physical characteristics were evaluated, as well as the effect of adding SPP on the sensory and textural properties of the chicken sausage samples. The emulsifying and wettability properties of SPP were found to be satisfactory, while low solubility behavior was observed. SPP slightly increased protein and decreased fat content, while the difference in moisture, salt, and pH values was insignificant.

It was observed from the sensory study that the panel members found acceptable sensory attributes (texture, color, taste, and overall acceptance) in SPP-added sausage. In summary, the addition of SPP positively impacted the textural and overall sensory quality of mini frankfurter-type chicken sausage.

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