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COMPARISON ON THE RHEOLOGICAL, PHYSICOCHEMICAL, AND TEXTURAL PROPERTIES OF SESAME MEAL PROTEIN ISOLATE AND SOY PROTEIN ISOLATE AS NOVEL PROTEIN SOURCES FOR MEAT ANALOGS

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I. INTRODUCTION

The rapid increase in global population and the corresponding surge in protein demand have raised significant challenges regarding protein supply and food security. Consequently, increasing numbers of research on plant-based proteins as meat analogs has been conducted. Soy protein isolate (SPI) has been the most extensively studied, due to its gelling ability and water holding capacity, making it suitable for meat analogs [1]. However, soy can be an allergenic food, restricting its consumption among certain consumer groups, and it is often unable to fully replicate the diverse textures, flavors, and nutritional characteristics of real meat [1]. Developing new plant-based protein sources is essential for offering a viable alternative or complement to current legume-based proteins. Sesame meal, a by-product of sesame oil extraction, has been underestimated, frequently discarded, or designated for animal feed. However, sesame meal has a high crude protein content (50%) establishing it as a promising protein source [2]. Upcycling sesame meal into sesame meal protein isolate (SMPI) not only addresses environmental concerns but also creates new economic opportunities as a sustainable food ingredient.

This study compares the rheological, physicochemical, and textural properties of meat analogs produced using SMPI and SPI. Results suggest SMPI presents a viable alternative or supplement to SPI in meat analog production, indicating potential for further exploration in this field.

II. MATERIALS AND METHODS

Sesame meal was provided by Queensbucket Co., Ltd. Sesame meal was defatted using hot water and then extracted by alkaline extraction method, followed by freeze-drying and named SMPI (crude protein content; 86.82%). SPI (crude protein content; 89.03%) was purchased and used from Jung Woo Korea Co., Ltd. Protein-water mixtures were prepared at different concentrations, and the number in the sample name indicates the mass ratio of proteins (w/w). Rheological measurements were performed using a rheometer (HR-10, TA instruments Ltd., USA) with a 40 mm parallel plate and a 1 mm gap. SMPI and SPI meat analogs were filled into a 35 mm petri dish, wrapped in plastic wrap, and then heated in a water bath at 90℃ for 20 min. Nuclear Magnetic Resonance spectroscopy (NMR) (MAC+, Oxford, UK) was used to evaluate water mobility. The raw data obtained from the NMR analysis were used to obtain three statistically significantly different multi-exponential components using the winfit program. Circular dichroism (CD) (J1700, Jasco Inc., Japan) was conducted to analyze protein secondary structure. Texture analysis (TA-XT Plus C, Stable Micro Systems, UK) was performed to measure compression and cutting forces.

III. RESULTS AND DISCUSSION

In the rheology analysis, SMPI showed higher moduli (G', G") than SPI at the same concentration, which means that SMPI has better protein solid gel formation ability than SPI when using the same amount of isolated protein in the production of meat analogs. In the programmed temperature sweep test, G' modulus increased similarly for both SMPI and SPI during heating, but SMPI increased more steeply, so the two curves crossed, and accordingly, the tan δ of SMPI decreased more significantly, indicating enhanced solid properties. The trends of G' and tan δ showed that SMPI had superior solid gel-forming capability to SPI, which indicates its high potential for use in the production of alternative meat.

Through mathematical fitting of the NMR relaxation curves, three statistically significant components were obtained, which implied that there might be three or more components with different water mobilities according to T_2 relaxation times. Therefore, based on their relative mobilities, the components were designated as the highest, intermediate, and lowest mobile phases. In SMPI, the T_2 relaxation time and relative proportion of the highest mobile phase water were 1.83 and 2.17 times higher, respectively, compared to those in SPI. Similarly, the least mobile phase water also exhibited a 2.14-fold increase in T_2 relaxation time and a 1.88-fold increase in the proportion. These findings

indicated that water associated with SMPI exhibited greater mobility than that associated with SPI, suggesting weaker protein–water interactions and stronger protein–protein interactions in SMPI [3].
In the CD spectrum, SMPI exhibited a higher β-sheet ratio compared to SPI. β-sheet -based interactions could promote a large inter-molecular binding between protein molecules, which resulted in stronger inter-molecular protein interactions to form structurally rigid network or polymeric aggregates [4].
The compression force, resilience, and cutting force values in the texture analysis were measured to be approximately 3, 2.5, and 5.5 times higher for SMPI than those for SPI, respectively. On the other hand, the adhesiveness was approximately 3 times higher for SPI than that for SMPI. These differences in physical properties could be due to the different features of protein-protein and protein-water interactions for each isolated protein.

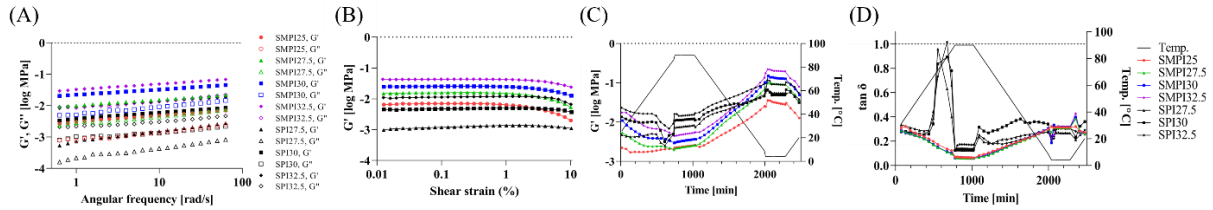


Figure 1. Rheological properties of SMPI and SPI at various concentrations.
(A); Frequency sweep test,(B); strain sweep test, (C); programmed temperature sweep test,
(D); tan δ value in programmed temperature sweep test.

Table 1. Texture analysis of meat analogs prepared with SMPI and SPI

	Compression force [g]	Adhesiveness [g·sec]	Resilience [%]	Cutting force [N/mm]
SMPI	12007.89±70.96	56.13±22.69	44.72±1.84	0.59±0.06
SPI	3920.83±194.79	159.71±38.03	18.51±0.40	0.11±0.01

IV. CONCLUSION

This study demonstrated that SMPI exhibited superior rheological, physicochemical, and textural properties compared to SPI when forming a gel. Rheological analysis showed that SMPI had higher G' and lower tan δ, indicating harder gel formation. NMR analysis results showed that SMPI exhibited higher water mobility, indicating weaker protein-water interactions and stronger protein-protein interactions than SPI. Higher β-sheet content in SMPI as measured in CD supported the stronger intermolecular bonding that could lead to forming a more rigid gel. Texture analysis results showed that SMPI exhibited higher compression and cutting forces and resilience than SPI. These results suggested that SMPI can be a potential substitute for SPI in meat analogs and provide improved structural and functional properties for the development of plant-based meat products.

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