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RESEARCH & EXTENSION
University of Arkansas System

Novel new functional edible protein films from soybean using innovative 3D printing technology

Mid-South Soybean Board Presentation

Project Number:	AWD-100936
Project Title:	Novel new functional edible protein films from soybean using innovative 3D printing technology
Organization:	Department of Food Science, University of Arkansas Division of Agriculture
Principal Investigator Name:	Dr. Ali Ubeyitogullari
Other investigators:	Dr. Navam Hettiarachchy

OBJECTIVES

1. Prepare soy protein isolate and hydrolysates from soybean seeds grown in Mid-South (lines AR-R11-7999 from Arkansas, MO-S17-19874R and MO-S17-17168 from Missouri).

2. Optimize conditions and prepare homogeneous film solutions with soy protein isolate, glycerol, malic acid and natural phenolic extract (antioxidant), and investigate flow properties.

3. Optimize conditions and extrude soy protein film using 3D printing technology, investigate the physical properties of the extruded films for color, tensile strength, and antioxidant activity of the extruded film.

Year 1

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Protein contents of ground soybean flour and protein isolate

Lot number	Protein content (%) by Kjeldahl method (dry weight basis) #, *	
	Ground soybean flour	Soy-protein isolate
	Protein content (dry weight basis)	Protein content (dry weight basis)
AR-R11-7999	40.0 ± 0.4[a]	84.5±2.5[a]
MO-S17-17168	39.1 ± 1.0[a]	84.7±2.9[a]
MO-S17-19874R	39.9 ± 0.5[a]	87.3±0.5[a]

Data are represented as mean ± standard deviation from three independent experiments. Mean values of protein content in soy-protein isolate followed by same letters in the same column are not significantly different ($P < 0.05$).
* Protein content was determined from the total nitrogen determination by Kjeldahl method using Kjeldahl factor 6.25.

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Physical properties of the final 3D printed edible soy-protein films

Sample #	Thickness (mm) #	Tensile Strength (MPa) #	Puncture strength (N) #	Water activity (a_w) (Measured at 25 °C) #	Density (g/cm³) (Measured at 27 °C) #	Elongation at break (%)#
AR-R11-7999	0.110 ± 0.010^{a}	14.89 ± 0.49^{a}	7.12 ± 0.32^{b}	0.34 ± 0.01^{a}	1.22 ± 0.07^{b}	105.7 ± 1.3^{a}
MO-S17-19874R	0.108 ± 0.008^{a}	14.79 ± 0.93^{a}	8.20 ± 0.46^{b}	0.33 ± 0.02^{a}	1.36 ± 0.09^{a}	104.4 ± 0.5^{a}
MO-S17-17168	0.114 ± 0.005^{a}	16.07 ± 1.89^{a}	6.97 ± 0.58^{a}	0.31 ± 0.01^{a}	$1.28 \pm 0.03^{a,b}$	104.7 ± 0.8^{a}

Data are represented as mean ± standard deviation from three independent experiments. Mean values of physical properties in soy-protein isolate followed by same superscripted letters in the same column are not significantly different ($P < 0.05$).

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Color parameters of the 3D-printed edible soy-protein films

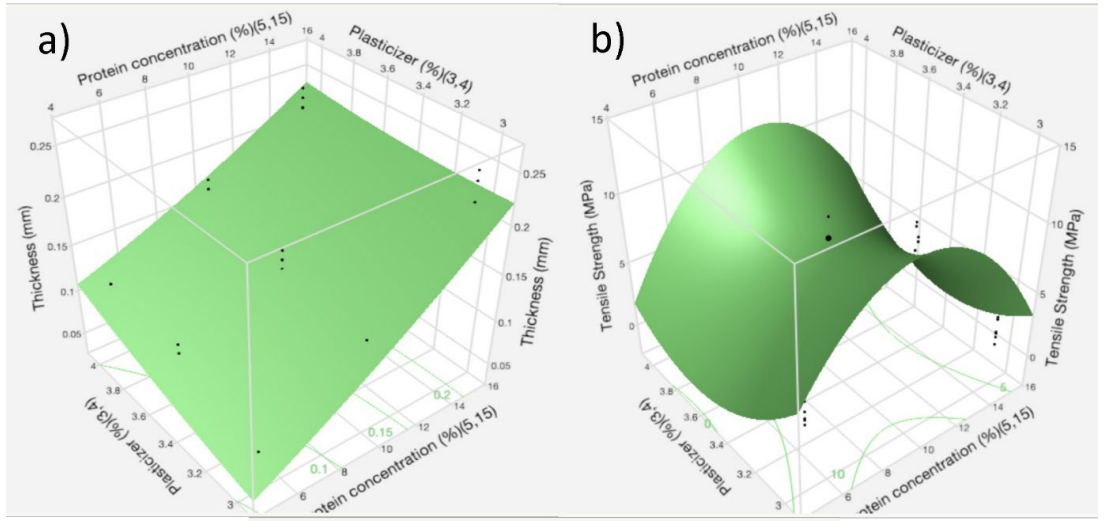
Sample #	L*[a]	a*[a]	b*[a]	Browning Index[a]
AR-R11-7999	91.30±0.18	-1.31±0.06	14.85±0.20	16.25±0.22
MO-S17-19874R	90.81±0.20	-1.89±.05	17.25±0.36	18.98±0.49
MO-S17-17168	91.53±0.44	-1.74±0.08	16.13±.33	17.56±0.38

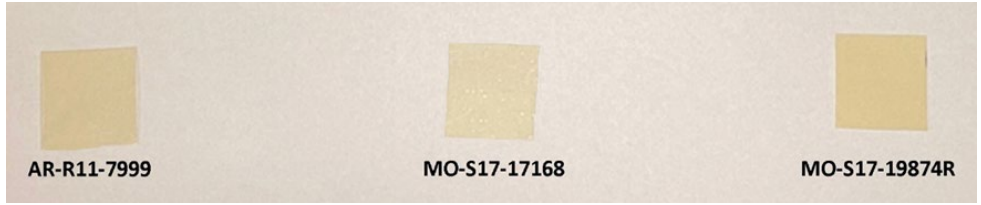
a Data are represented as mean ± standard deviation from three independent experiments.

Year 1

Response surface plots, from the experimental results of the central composite design (CCD) representing the interactions between the independent variables:

(a) Thickness,
(b) Tensile strength, and
(c) Puncture strength





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Physical and Textural Properties of Functional Edible Protein Films from Soybean using an Innovative 3D Printing Technology

Sriloy Dey[1], Navam Hettiarachchy[1*], Ali A. Bisly[1], Kaushik Luthra[1], Griffiths G. Atungulu[1], Ali Ubeyitogullari[1,2*] , Leandro Angel Mozzoni[3], and Pengyin Chen[4]

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Year 2

Objective 2: Optimize conditions and prepare homogeneous film solutions with soy protein isolate, glycerol, malic acid and natural phenolic extract (antioxidant), and investigate flow properties

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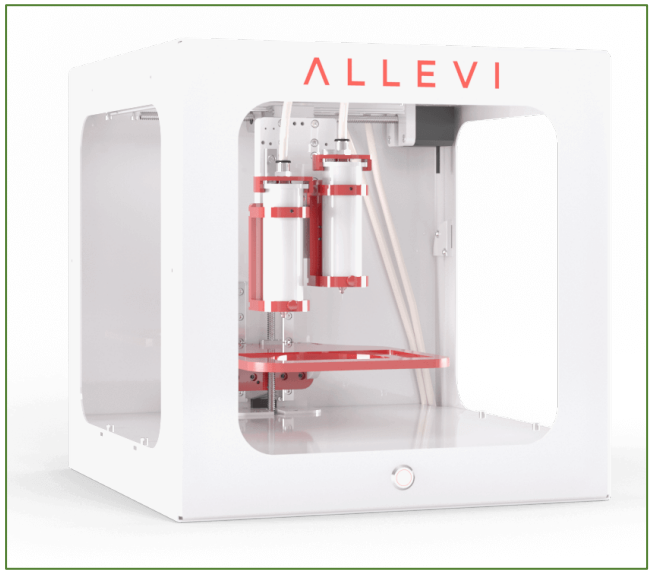
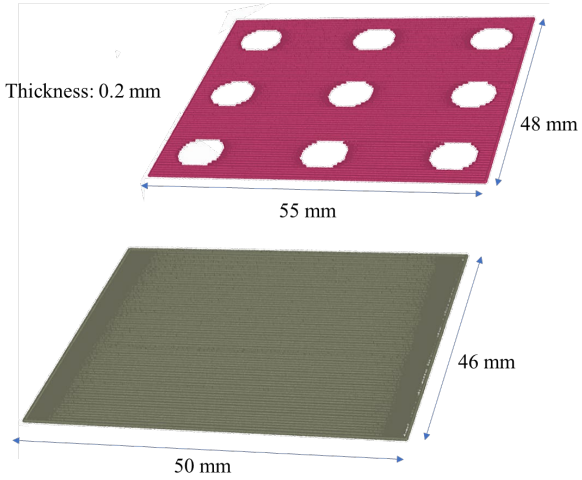
3D Food Printer



The 3D food printer can be operated at:

- various temperatures (room temperature – 160 °C),
- pressures (1 – 120 psi), and
- speeds (1-20 mm/sec) with
- X, Y, and Z precisions of 5, 5, and 1 µm, respectively.



Year 2

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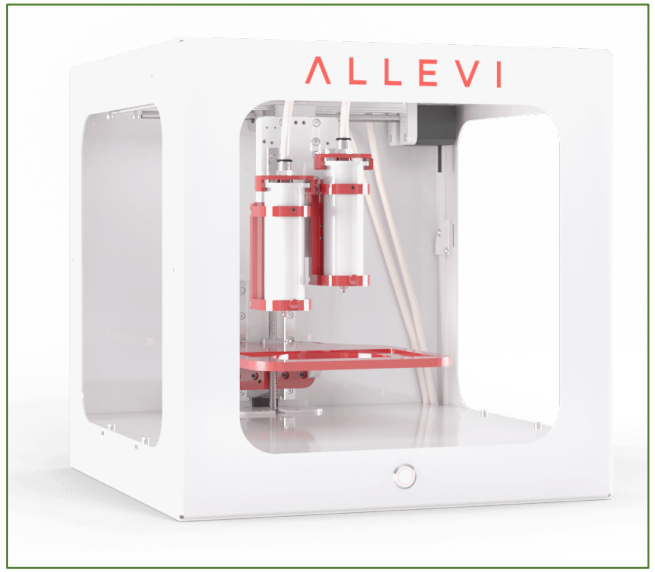

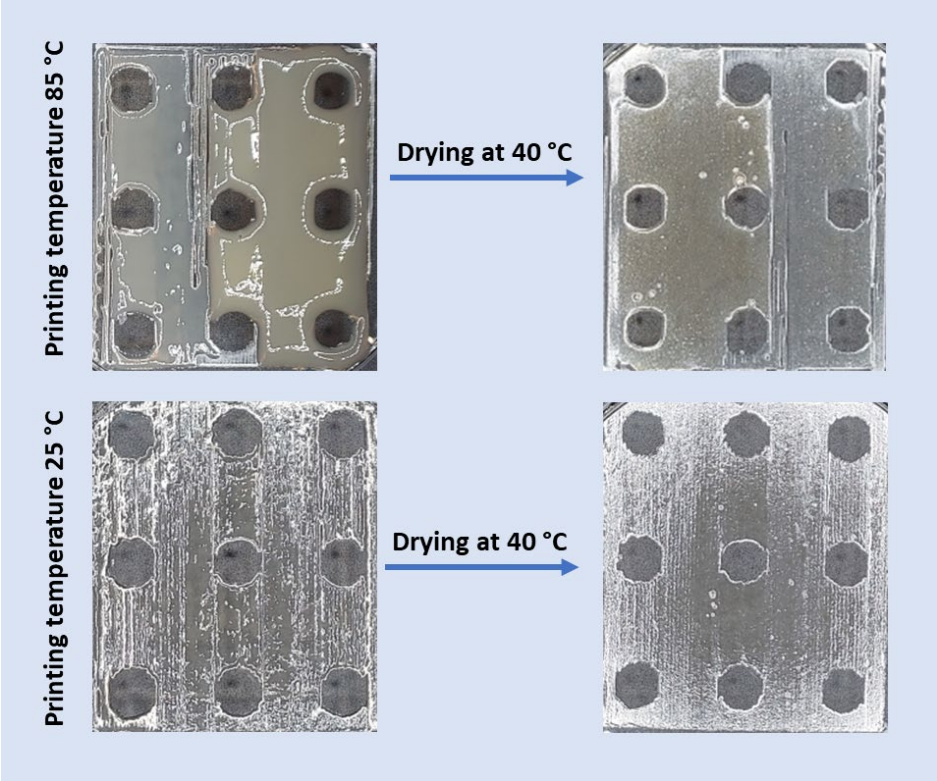

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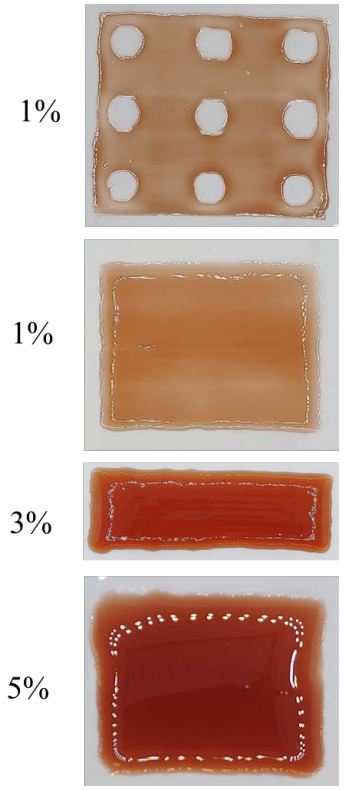
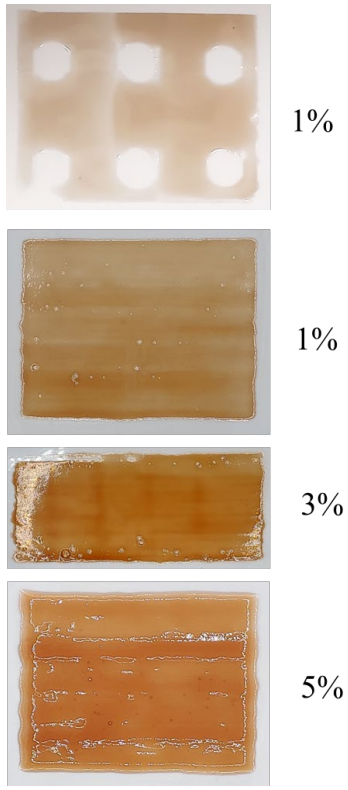
Grape seed extract



Green tea extract



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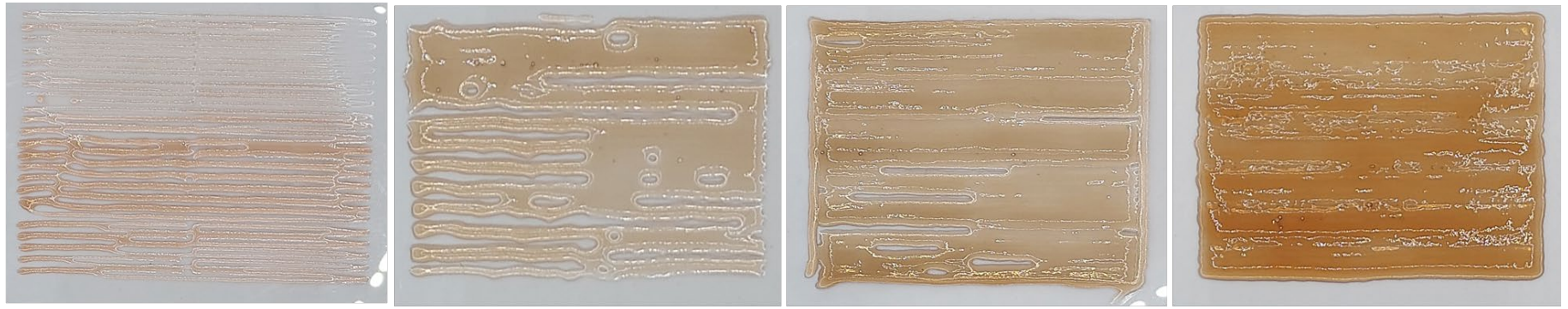
The effect of 3D printing pressure



Printing pressure	3 psi	5 psi	7 psi	9 psi

Research in Progress

Optimize conditions of 3D printing, investigate the physical properties of the extruded films for color, tensile strength, and antioxidant activity of the extruded film.