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FUNCTIONALITY OF SOY PROTEIN ISOLATES IN SOY BREAD DURING STORAGE

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ABSTRACT

Two pound loaves of soy bread containing undenatured and partly denatured soy protein isolates, SPI (approximately 12% replacement of wheat flour) were produced and stored for 7 days in polyethylene bags. Control soy bread were prepared for comparison. Protein denaturation in soy milk powder, SMP, was evaluated by differential scanning calorimetry, DSC. Physical measurements (water activity, loaf volume, crumb and crust color), chemical analysis (protein, ash contents), thermal analysis (thermal gravimetric analysis TGA, differential scanning calorimeter DSC and dynamic mechanical analysis DMA) and mechanical analysis (firmness with Instron testing machine) were performed.

Increased soy protein content in soy bread decreased loaf volume. Moisture retention of soy breads containing SPI and SMP was greater when compared with control soy breads. 'Freezable' water contents of SMP added soy bread and partly denatured SPI soy bread were more stable during storage as compared to control soybread. 'Unfreezable' water decreased in all formulations during storage. Amylopectin recrystallization for undenatured SPI and control soy breads was similar, whereas partly denatured SPI soy bread had similar behavior to that of SMP added soy bread. DMA results indicated that stiffness increased with storage. Lighter crumb color was observed for samples with increased soy protein content.

Soy protein addition to soy bread formulation had different effects on the bread quality depending on the protein denaturation of the ingredients.

INTRODUCTION

Soy bread with its high content of soy protein, isoflavones and dietary fiber is a potential functional food.

FDA links consumption of soy protein with a lower risk of heart disease. Additionally, soy products are being recognized as having potential roles in the prevention and treatment of chronic diseases, such as cancer, osteoporosis, kidney disease and reduction of blood cholesterol levels.

In order to successfully incorporate soymilk in bakery products, an understanding of the impact of this ingredient on physico-chemical properties of such products is necessary.

Previous studies on addition of soy to bread showed a significant decrease in bread loaf volume as a result of different water absorption properties of soy ingredients and/or dilution of gluten fraction (Vittadini and Vodovotz, 2003) .

Addition of SMP improved the quality of soy bread. To better understand the role of SMP in soy bread, the main components (denatured and undenatured soy proteins) of soymilk powder were evaluated.

OBJECTIVE

To determine the functionality of partly denatured and undenatured SPIs in soy bread during storage as compared to control soy bread and soy bread with SMP.

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EXPERIMENTAL PLAN

Bread Baking

- Control (only soy flour) (ADM Ingredients, USA)
- Control with soymilk powder (Devansoy, USA)
- Soy protein isolate PROLISSE™ (Cargill Inc., USA)
- Soy protein isolate PROFAM 891 (ADM Ingredients, USA)

Soy Bread Baking
(Duplicate 30 % Soy, 2 lb 2 loaves for each formulation)

Cooling and 7 days of storage at 25 °C

Physical measurements	Chemical Analysis	Thermal analysis
Water activity Loaf Volume Color Texture	Ash Protein (duplicate analysis)	TGA DSC DMA

MATERIALS AND METHODS

Thermal Analysis (duplicate analysis for each two loaves)

- DSC 5°C/min, – 60-150 °C, 10 mg sample size. (TA Instrument DSC 2920)
- TGA 20°C/min 25 -180 °C, 20mg sample size (TA Instrument TGA 2950)
- DMA 2°C/min, – 80-180 °C, 14.285 x 9.3 x 2.9 mm sample geometry (TA Instrument DMA 2980). Dual cantilever clamp, bending mode.
- Texture (Instron 5542) 15mm dia. 25 mm thickness small cylinders. 8 measurement for each specimen, from center of 2 loaves. 100 mm/min rate of compression (Hallberg & Chinachoti, 2002)
- Color (Minolta Chromameter CR 300) Five readings from 10 different points for each loaf.
- Loaf volume (seed displacement method)
- Proximate analysis (ash – furnace method, protein-Kjeldahl method)

CONCLUSIONS

Increased soy protein content in soy bread decreased loaf volume.

Increased soy protein content improved moisture retention properties of the soy breads

'Freezable' water contents of SMP added soy bread and partly denatured SPI soy bread were more stable during storage as compared to control soybread. Undenatured SPI showed an increasing trend for 'freezable water' content during storage.

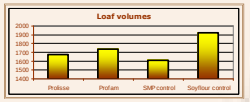
SMP addition to soy bread significantly decreased amylopectin crystallization. Undenatured soy protein isolate resulted in a similar trend as control soy bread, whereas partly denatured SPI soy bread had similar behavior to that of SMP added soy bread. Significant reduction of amylopectin crystallization can be related with other components of SMP such as soluble fiber.

Firmness obtained by Instron was higher for undenatured SPI added soy bread, and also stiffness obtained by DMA results were higher than that of others at the end of storage.

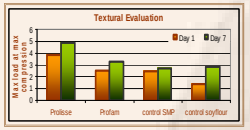
Soy protein addition to soy bread formulation had different effects on the bread quality depending on the protein denaturation of the ingredients.

RESULTS AND DISCUSSION

PHYSICAL MEASUREMENTS



Bread loaf volumes for each formulation



Maximum load at maximum compression values at day 0 and day 7.

Highest loaf volume was obtained by soyflour control bread whereas SMP control bread has the lowest value.

Water activity values were stable for each formulations and found to be in the range of 0.966-0.969 at the end of storage.

During storage firmness increased for all bread samples. Soy protein addition increased firmness of breads. Undenatured SPI added bread had greater firmness with respect to others.

EVALUATION OF COLOR

HL values, a values and b values for each bread crumb color and crust color

Soybread with	Crumb						Crust					
	Day 1			Day 7			Day 1			Day 7		
	HL	a	b	HL	a	b	HL	a	b	HL	a	b
Prolisse	59.2	1.91	18.0	59.1	1.99	17.7	22.6	6.94	5.58	21.6	7.12	5.28
Profam	58.4	1.59	17.9	60.6	1.54	17.8	21.5	6.56	5.28	20.3	6.99	5.29
Control SMP	57.8	2.24	18.7	60.0	1.98	19.1	22.4	7.30	5.74	20.4	7.55	5.64
Control soyflour	55.3	1.16	16.7	57.0	0.77	16.5	22.9	5.84	4.83	21.2	6.81	5.09

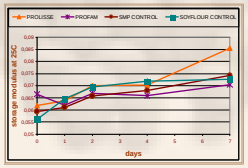
Lighter crumb color was observed for samples with increased soy protein content. Crumb lightness increased with storage. SMP involving bread was more yellowish than others. Crust colors seemed to get darker during storage. Undenatured SPI added bread had the lightest crust color.

L value indicates lightness, whereas a value is 'a' scale for red (+), gray 0 and green (-) and 'b' value scale for yellow (+), gray 0 and blue (-).

CHEMICAL ANALYSIS

Protein and ash contents for each bread formulation.

Soy bread with	Ash (%) dmb	Protein (%) dmb
Prolisse	5.19	15.96
Profam	5.27	16.49
SMP Control	5.02	16.40
Soyflour control	5.01	13.91



Change in storage modulus values at 25 °C with storage

DMA results indicated that stiffness increased with storage, especially for Prolisse.

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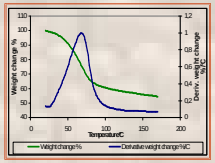
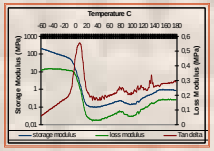
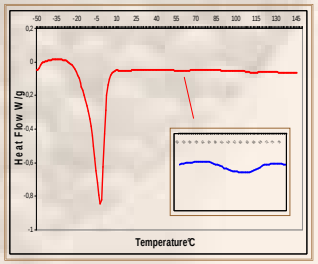
THERMAL ANALYSIS



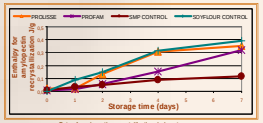
Typical TGA thermogram for soy bread



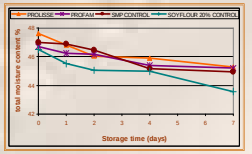
Typical DMA thermograph for soy bread



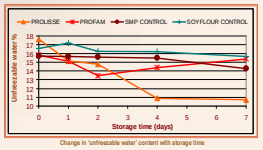
A typical DSC thermogram for soy bread samples



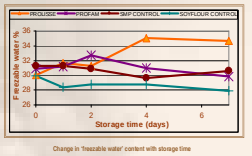
Rate of amylopectin recrystallization during storage



Change in total moisture content with storage time



Change in 'unfreezable water' content with storage time



Change in 'freezable water' content with storage time

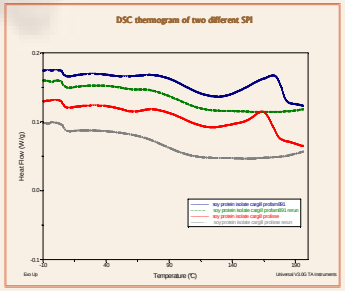
'Unfreezable water' content decreases during storage for all formulations, Prolisse having the sharpest decrease.

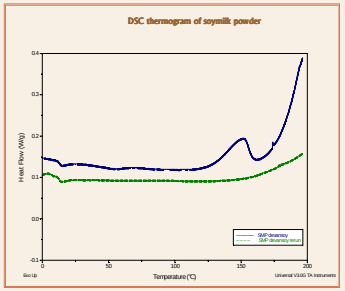
Moisture content (%) and 'freezable water' content(%) of formulations at the beginning and end of storage period.

	Day	Prolisse	Profam	SMP	Control
Moisture Content (%)	0	48	47	47	47
	7	45	45	45	44
'Freezable water' (%)	0	30	31	31	30
	7	35	30	31	28

Around 60-70°C and 110-120°C two endothermic peaks were observed in DSC indicating the 7S and 11S fractions of soy proteins (Ma et al, 1997). A rescan of the samples resulting in no peaks was evidence of the protein denaturation.

For SMP samples the observed peaks were very small and therefore the protein was mostly denatured. In order to simulate the effects of soy proteins of SMP, SPI (PROFAM 891) involving mostly denatured soy protein fractions was selected.





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