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FUNCTIONALITY OF SOYMILK POWDER IN SOY BREAD DURING STORAGE

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ABSTRACT

Soymilk powder (SMP) is composed of functional ingredients such as soy proteins, isoflavones, soluble and insoluble dietary fiber components. 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 needed.

Two pound loaves of soy bread containing added soluble and insoluble soy fibers, undenatured and partly denatured soy protein isolates, soy fibers and soy protein isolates in the same amount present in soymilk powder were produced and stored for 7 days in polyethylene bags. Physical measurements (water activity, loaf volume, loaf height, loaf density, color), chemical analysis (soluble and insoluble dietary fiber contents, 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.

SMP addition to soy bread formulation decreased loaf volume and height. Moisture retention properties of the soy breads involving soy protein isolate, soy fiber and SMP were higher when compared with control soy bread sample. "Freezable" water content decreased for all samples except those with undenatured soy protein isolate while the "unfreezable" water content decreased for all formulations except for those with fiber. SMP addition to soy bread significantly decreased amylopectin crystallization while insoluble fiber increased amylopectin crystallization. From DMA results it was observed that stiffness increased with storage for all formulations. Lighter crumb color was observed for soy breads formulated with SMP.

SMP addition to soy bread is highly recommended for its positive effects both on health and on bread keeping quality.

INTRODUCTION

Soy bread with its high content of soy protein, isoflavones and dietary fiber is a potential functional food. Increasing the dietary fiber content in bakery products has been shown to improve the water holding capacity and shelf life properties yet some detrimental effects on bread quality may result.

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.

Soy Bread with SMP had better properties with respect to normal soy bread. To find out the causes for this, main components of soymilk powder are evaluated:

o Dietary fiber (soluble and insoluble part)
o Soy proteins (denatured and undenatured)

OBJECTIVES

• To understand the impact on soy bread physical properties upon addition of soymilk powder.

EXPERIMENTAL PLAN

Bread Baking

o Control (only soy flour) (ADM Ingredients, USA)
o Control with Soymilk powder (Devansoy, USA)
o Soy Soluble fiber SOYAFIBE DA 100 (Fuji Oil Co. Ltd., Japan (1% of wheat flour)
o Soy insoluble fiber SOYFIBRIM (Solae Company, USA) (4% of wheat flour)
o Soy protein isolate PROLISSE™ (Cargill Inc., USA)
o PROLISSE+ SOYAFIBE+ SOYFIBRIM
o Soy Protein Isolate PROFAM 891 (ADM Ingredients, USA)

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

Cooling and storage (7 days)

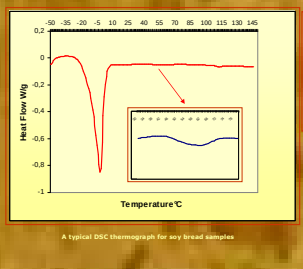
Physical measurements	Chemical Analysis	Thermal analysis
Water activity, Volume, weight, height Color (HunterLab colorimeter) Texture (Instron)	Ash Protein Dietary fiber (duplicate analysis)	TGA DSC DMA

MATERIALS AND METHODS

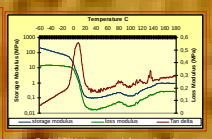
Thermal Analysis (duplicate analysis for each two loaves)

☐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 for bending.
☐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.
☐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)
☐Total & Soluble dietary fiber determination (AOAC 991.43 Enzymatic - Gravimetric Method) for all bread formulations.

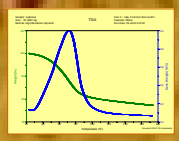
THERMAL ANALYSIS



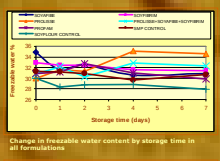
A typical DSC thermograph for soy bread samples



Typical DMA thermograph for soy bread

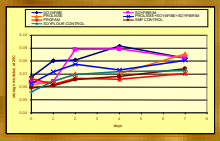


Typical TGA thermogram for soy bread



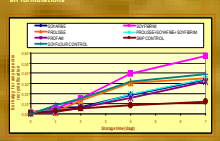
Change in freezable water content by storage time in all formulations

• Except the undenatured SPI formulations all bread formulations had decreasing 'freezable' water content.
• 'Freezable' water content was lowest in normal soy bread.
• SMP bread had similar trend with soluble fiber formulation.



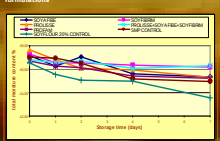
Change in storage modulus values at 25 °C by storage for all formulations

• Stiffness increased by storage time.
• Undenatured SPI had similar behaviour with control breads.
• Dietary fiber ingredients resulted in stiffer soy bread.



Rate of amylopectin recrystallization by storage time for all formulations

• Insoluble fiber increased amylopectin crystallization.
• Whereas soluble fiber and undenatured SPI ingredients decreased staling.
• Lowest enthalpy for SMP could be the synergistic effect of soluble fiber and undenatured soy proteins



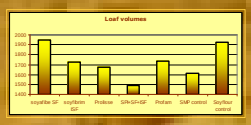
Change in total moisture content by the storage time for all bread formulations

• For all formulations there was a decreasing trend.
• Control soyflour bread had the lowest moisture content.
• Both the insoluble fiber and undenatured SPI formulations had ability to keep moisture.

RESULTS AND DISCUSSION

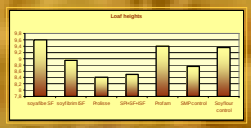
PHYSICAL MEASUREMENTS

• Highest loaf volume was obtained by soluble fiber.
• Insoluble fiber especially with SPI resulted in the lowest loaf volume.



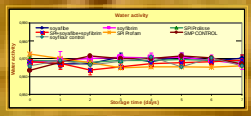
Bread loaf volumes for aech formulation

• Soluble fiber resulted in the maximum loaf height.
• Soy protein isolate with dietary fiber decreased the loaf height.



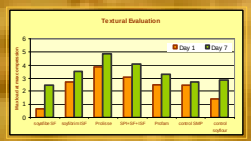
Bread loaf heights for aech formulation

• Water activity values seemed to be similar for each formulations.
• SMP and dietary fiber formulations seemed to have slightly higher water activity values with respect to SPI and control soy breads.



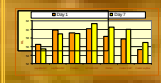
Change in water activity values by storage for all formulations

• During storage firmness increased for all bread samples. SPI addition increased firmness of breads. Whereas, soluble fiber resulted in softer soy breads.

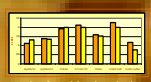


Maximum load at maximum comression values for each formulation at day 0 and day 7.

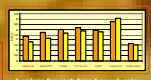
Evaluation of Color



HL values for each bread crumb color



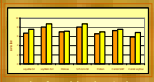
a values for each bread crumb color



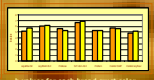
b values for each bread crumb color

• 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 (-).
• Except the fiber added formulations all crumb lightness increased by storage. SMP addition increased lightness of crumb with respect to control soy bread.
• SMP involving bread was more yellowish than others.
• When crust colors were evaluated for all formulations crust colors seemed to get darker during storage.
• This darkening was minimum for soluble fiber addition.
•For all days undenatured SPI added bread had the lighter color for crust.

HL values for each bread crust color



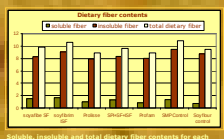
a values for each bread crust color



b values for each bread crust color

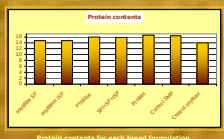
CHEMICAL ANALYSIS

• Soluble fiber content of SMP was higher with respect to control soyflour bread as expected.
• Soy fiber added formulations had similar amounts of fiber with SMP added bread.

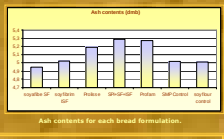


Soluble, insoluble and total dietary fiber contents for each bread formulation.

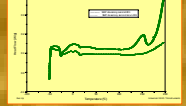
• Ash contents for SPI and three combination formulations were greatest.
• Protein addition by SPI simulated the protein content of SMP added soy bread.



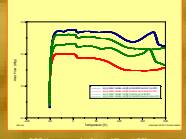
Protein contents for each bread formulation.



Ash contents for each bread formulation.



DSC thermograph of soymilk powder



DSC thermograph of two different SPI

• Around 60-70°C and 110-120°C two endothermic peaks were observed indicating the 7S and 11S fractions of soy proteins.
• A rescan of the samples showing 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 involving mostly denatured soy protein fractions was selected.
•PROFAM 891 gave the best result for this purpose.

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

	Day	Soyafibe	Soyfibrim	Prolisse	Soyafibe+ Soyfibrim+ Prolisse	Profam	SMP	Control
Moisture Content (%)	0	47,18	47,27	47,63	46,83	46,69	47,00	46,52
	7	45,33	46,18	45,30	46,30	45,21	44,93	43,55
Freezable water (%)	0	34.92	32.99	30.03	30.78	30.87	31.31	29.97
	7	30.91	31.44	34.61	32.32	29.84	30.65	27.90

CONCLUSIONS

• Soymilk powder addition to soy bread formulation decreased loaf volume and height. This decrease could be related to the insoluble fiber and soy protein content of this ingredient.
• Moisture retention properties of the soy breads involving soy protein isolate, soy fiber and soymilk powder were higher when compared with control soy bread sample.
• Soymilk powder addition to soy bread significantly decreased amylopectin crystallization while insoluble fiber increased amylopectin crystallization. Soluble fiber decreased amylopectin crystallization when compared to control soy bread Undenatured soy protein isolate resulted in a similar trend as control soy bread for amylopectin crystallization, whereas partly denatured soy protein isolate soy bread had similar behavior to that of soymilk powder added soy bread.
• For fresh soymilk powder added soy bread, firmness was higher with respect to control soy bread whereas after 7 days of storage firmness remained stable and became lower than that of control bread. This stability can be the result of soluble fiber content of soymilk powder.
• Lighter crumb color was observed for soy breads formulated with soymilk powder. It may be related to the increase in the soy protein content and insoluble soy fiber content. Crust colors were darker for all formulations after 7 days of storage and the increase in darkness in soy crust may be the cause of partly denatured soy protein.
• Soymilk powder addition to soy bread is highly recommended for its positive effects both on health and on bread keeping quality.

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