Effect of Soy on Bread's Physico-chemical Properties During Storage

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Abstract

The addition of soy ingredients to bread can improve protein quality of the product. More recently, research has shown that soy contains isoflavones which may act against human cancer development. Few of these products are on the market since soy causes a significant decrease in loaf volume and acceptability. A better understanding of the physico-chemical changes in such breads, especially during storage, may lead to acceptable formulations.

The objective of this work was to compare the physical states of whole wheat and soy breads and their components during storage.

Wheat and soy containing breads ("soy bread") were stored in polyethylene bags at room temperature for up to 7 days. The state of bread and its components was analyzed by Dynamic Mechanical Analysis (DMA) and Differential Scanning Calorimetry (DSC). Additionally, solid state ^{13}C NMR spin lattice relaxation time (T_1) was analyzed for changes in the carbon-chain motion.

Both soy and wheat breads showed a major transition around 0 °C (DSC and DMA) attributed largely to ice melting. Additionally, a transition around 60°C (DSC) was observed upon storage and it was attributed to amylopectin recrystallization. Amylopectin recrystallization increased at a much greater rate in wheat bread than in soy bread during storage. For fresh soy bread the T_1 (Carbon 6) was 0.53 sec and showed a single-phase relaxation while aged bread T_1 (Carbon 6) was found to best fit a two-phase relaxation (7.9 sec and 0.18 sec), indicating a greater heterogeneity after storage. Wheat bread showed similar trend and T_1 values.

Addition of soy to bread changed the physical state of the bread polymers and seemed to decrease the deleterious effects of storage.

Introduction

Research has shown that soy contains chemopreventive agents (isoflavones) acting against human cancer development (Fukutake et al., 1996) and there are promising signs that soy may also reduce bone loss (Omi et al., 1994) and inhibit atherosclerosis (Clarkson and Anthony, 1998). Therefore, the incorporation of soy-containing products into the diet has become increasingly more significant in the food industry.

Blending of soy flour into wheat bread causes a significant decrease in loaf volume (Buck et al., 1987; Fleming and Sosulski, 1977) and a decrease in acceptability (Fleming and Sosulski, 1977; Brewer et al., 1992). The ability to produce an acceptable bread with appropriate texture and volume relies on understanding the interaction between starch and gluten which results in the proper formation of a gluten network.

The study of the effect of the addition of soy protein to bread formula on the thermal and molecular properties of bread during storage might lead to the understanding of the events taking place in the product and allow for formulation of an acceptable soy bread.

In this work the changes occurring in bread (wheat and soy) were analyzed at macroscopic (moisture content), macromolecular (DSC and DMA) and molecular (^{13}C NMR) levels.

Materials

"Soy bread" (20% soy flour)

Wheat Bread control

→ Baked (2 lb. Loaf) ZOJIRUSHI BBCC-V20 Bread Machine (Zojirushi Corp. Osaka Japan)

→ Cooled for 1hr at room T

→ Packed in polyethylene bags

→ Stored at room T for 7 days.

Moisture Content:
Wheat Bread: 37%
"Soy Bread": 42%
Constant during storage

Methods

Nuclear Molecular Resonance (NMR)

(300MHZ, Bruker)
- ^{13}C CPMAS
- ^{13}C T_1 spin-lattice relaxation time

Differential Scanning Calorimetry (DSC)

(TA Instrument, DSC2920)
Heating Rate: 3 °C/min
Temp Range: -50 °C – 110 °C
Sample Size: 8 - 10 mg

Dynamic Mechanical Analyzer (DMA)

(TA Instrument, DMA2980)
Heat Rate: 2°C/min
Temp Range: -80 °C – 110°C
Sample Geometry: 14.00 x 9.50 x 2.90 mm

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Results & Discussion

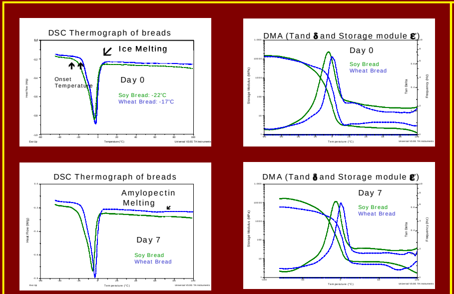

Figure 1,2,3 & 4. DSC and DMA results of wheat & soy bread during storage.

Both wheat and soy bread showed a major transition around 0°C attributed largely to ice melting. Soy bread showed a broader transition around O°C (both DSC and DMA) with onset at lower temperature (-22°C) than for wheat bread (-17°C) (1). This might be due to a possible overlapping of a second phase transition in this sample as compared to wheat bread. Upon storage, a second endothermic peak at 50-60 °C was detected by DSC and it was attributed to the melting of recrystallized amylopectin. The fall in DMA storage modulus (E') with increasing temperatures was sharper for wheat bread than for soy bread suggesting broader phase transition in soy bread.

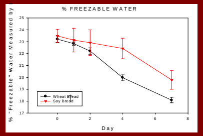

Figure 5. DSC "freezable" water of wheat and soy bread during storage. The "freezable" water content of both soy and wheat bread decreased during storage. Small and not significant differences between breads where found up to 2 days of storage. At longer storage times, "freezable" water content of wheat bread decreased more significantly than soy bread.

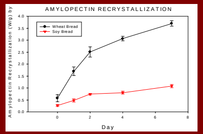

Figure 6. Enthalpy of DSC amylopectin melting in wheat and soy bread during storage. Amylopectin was found to recrystallize during storage for both soy and wheat breads. Amylopectin recrystallized more extensively in wheat bread as compared to soy bread.

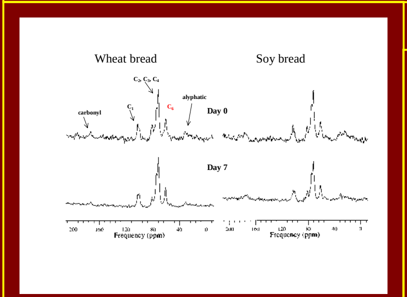

Figure 7. ^{13}C CPMAS spectra for wheat and soy containing bread both fresh and 7 days old.

Better signal to noise ratio was obtained upon sample ageing, as consequence of increased crystallinity of the sample. T_1 relaxation rate was calculated for the C6 carbon (figure 8)

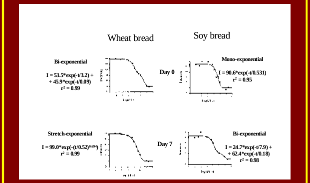

Figure 8. C_6 (61 ppm) ^{13}C T_1 relaxation rate for wheat and soy containing bread both fresh and 7 days old.
T_1 was found to change from amore homogeneous to a more heterogeneous behavior in both samples.
In wheat bread peak intensity (as f(time)) was best fitted with a bi-exponential function at time 0 (3.2 and 0.09 sec) and with a stretch exponential at time 7 days indicating a distribution of relaxation times.
Fresh soy bread T_1 was 0.53 sec and showed a single-phase relaxation while aged soy bread T_1 was bi-exponential (7.9 sec and 0.18 sec.

Conclusions

Addition of 20 % soy proteins to the bread formulation caused:

- Increased moisture content of the bread (42% soy vs 37% wheat)
- Comparable amount of "freezable" water in the fresh sample (~ 23 %).
- Lower decrease in "freezable" water during storage as compared to the wheat control.
- Lower amylopectin recrystallization during storage as compared to the wheat control.
- Main thermal transition (~0°C) to span a larger temperature range.
- More homogeneous molecular relaxations as indicated by ^{13}C T_1 relation times (mono-exponential vs bi-exponential in fresh bread and bi-exponential vs multiple-exponential on day 7 of storage in soy and wheat, respectively.