THE DETERMINATION OF THE EFFECTS OF SOAKING AS A PRETREATMENT FOR SOYBEANS

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Abstract. In this study, it was intended to determine the soaking behaviour of soybeans. Soybeans are legumes, which, as a family are rich in proteins, carbohydrates, dietary fiber, vitamins, and minerals. In order to obtain the edible form of legumes, they are processed through pre-treatments such as soaking, grinding and cooking. The soaking process, which is one of the most important pre-treatments, results in gaining water, easiness of the cooking, and reduction of the cooking time. In this study, the effects of different soybean:water ratios (1:2.5, 1:5, 1:10, and 1:20 (weight:weight) (w:w)) and the salt concentrations (1, 2, and 5%) and temperatures of the soaking medium (4, 25, and 80°C) on the total soluble solid content of soaking medium and colour values of the soybeans were examined with their effects on the weight gain of soybeans. According to the results of the analyses, a higher rate of weight gain values was observed for the experiments performed at 80°C. In general, the total soluble solid contents of the soaking medium, which indicates the loss of solids, were found to be inversely proportional to the amount of water both for the experiments in water and brine.

Keywords:

Pre-treatment, soaking, soybeans, weight gain, solid loss

INTRODUCTION

Soybeans (*Glycine max*) being a high protein legume, can be processed into many food products which have advantages of cost and utilization, when compared to most foods and proteins of animal origin (Beleia et al., 2006). It is an important crop which is used in human and animal nourishment with % 18-20 oil and % 40-45 protein content (Unakıtan & Aydın, 2012).

The soaking process which is one of the most important pre-treatments, results in gaining water, easiness of the cooking, and reduction of the cooking time. Main components of the solid lost into the soaking and cooking water are known to be carbohydrates and proteins (Wang et al., 1979). On the other hand, the solid loss has the advantage of losing some antinutritional factor such as phytates, enzyme inhibitors (trypsin, chymotrypsin and a-amylase) and hemaglutinins, which are primary reasons for the discomfort associated with consuming legumes (Abd El-Hady & Habiba, 2003). However, high solid loss during soaking and cooking of legumes decreases the nutritional and economic value of the final product (Unakıtan & Aydın, 2012). The loss was

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reported to be between 2 and 19% (wet basis, wb) of the total solid, depending on the water temperature, type of seeds and physiochemical defects on seeds (Agustin et al., 1989; Kon, 1979; Seena &Sridhar, 2005).

Temperature increases the rehydration rate but usually does not play a significant effect on rehydration capacity. The effect of temperature on rehydration rate is due both to the decreased viscosity of the immersion medium and to the effects of temperature on the food material structure. Temperature effects are usually described by an Arrhenius-type relationship (Ilincanu et al., 1997; Thakor et al., 1995).

In this work, the aim was to determine the soaking behaviour of soybeans. According to the experimental data the moisture content, rehydration rate, colour changes and the total soluble solid content changes of the soaking medium were determined depending on the changes of soybean:water ratio, salt concentration and temperature.

MATERIAL AND METHOD

Material

The soybeans in dried, commercial form were obtained from a local market in Izmir, Turkey.

Methods

The moisture content of the soybeans and rehydrated soybeans was determined according to AOAC, 2000. The colour values of the soybeans (L*, a*, and b* values) were measured with the Minolta CR-400 Colorimeter, Japan and the results were expressed in accordance with the CIE Lab. System.

Rehydration experiments were carried out in distilled water at refrigeration temperature (4±1°C), room temperature (25±1°C) and in hot water (80±1°C). The samples (10±0.5g) were weighed in a string bag and placed inside a beaker. For the experiments, the soybean:water ratios were adjusted to 1:2.5, 1:5, 1:10, and 1:20 (w:w). To observe the effects of different salt concentrations, brines of 0%, 1%, 2%, and 5% salt concentrations (w:w) were prepared and at every soybean:water ratio the experiments were repeated.

The samples were removed from water, drained, and their weight was measured for every 15 min for the first hour of the rehydration, then repeated every 30 min until the end of the 6th hour . After this, samples were weighed every hour until the 10^{th} hour of the rehydration. The rehydration ratio of the samples were determined by using Eq. (1) (Filli & Nkama, 2007) and the weight gain calculations were done by using Eq.(2) (Svihus et al., 1997).

The total soluble solid content (TSSC) of the rehydration medium was determined by digital refractometer (RFM 330, UK).

The data was analyzed using the statistical software SPSS 21.0 (SPSS Inc., USA). The data was subjected to an analysis of variance (ANOVA) which was used to determine the difference between means. The drying and rehydration experiments were replicated twice and all the analyses were triplicated

$$Rehydration\ Ratio - \frac{Weight\ of\ the\ rehydrated\ material\ (kg)}{\textbf{Weight of the initial material (kg)}} \quad (1)$$

$$Weight\ Gain(\%) = \frac{\left[\left(Weight\ of\ the\ rehydrated\ material\ at\ a\ time (kg)\right) - \left(\textbf{Weight of the initial material}\ (kg)\right)\right]}{\textbf{Weight of the initial material (kg)}} x100 \quad (2)$$

RESULTS AND DISCUSSION

The legumes are sold in dry form and they have to be processed prior to consumption (Agustin et al., 1989; Vidal-Valverde et al., 2002). Soaking is an integral part of a number of treatments, such as cooking, canning, germination, and fermentation. It consists of hydration of the seeds in water, usually until they reach maximum weight, with or without discarding of the soaking medium, and the results obtained depend of factors such as legume genus, species and variety, process duration, temperature, pH, salinity of the soaking media, and also the storage conditions undergone before processing (Prodanov et al., 2002). The initial moisture content of the soybeans was found to be 39.95% (wet basis, wb). The results of the moisture content of analysis for rehydrated soybeans are given in Table 1.

The results showed that the moisture content values of the rehydrated soybeans, generally increases with the increasing water to soybean ratios and temperature of the soaking medium. The increase of water to soybean ratio beyond 5:1 (w:w) significantly affects the moisture content values compared to the ratio of 2.5:1 (w:w) ($P<0.05$), however, further increase does not have any significant effect ($P>0.05$). Similarly, the effects of temperature and salt concentration of the soaking medium were found to be significantly affecting the moisture content ($P<0.05$). Considering the same soybean to water ratio values, increase of temperature leads to an increase of the moisture content values due to the increased rate of molecular movement and possible structural deformations at high temperatures. Depending on the results of the moisture content determination, the salt concentration of the soaking medium and the moisture content are inversely proportional whereas, the ratio of water:soybean and the moisture content values are directly proportional.

The initial color values (L*, a*, and b*, CIE Lab System) of the soybeans were found to be 71.19 ± 2, 2.13 ±0.06, and 9.7 ±0.14 respectively. As shown in Fig. 1, the a* values of the rehdyrated soybeans decreased, however, the b* value fluctuated during soaking pretreatment. The brightness values of the rehydrated soybeans were not significantly affected the soybean:water ratios ($P<0.05$). The results of the colour measurements indicated that the brightness (L*) values of the soybeans are increasing depending on the salt concentrations for 25°C and 80°C, however, the values at 4°C shows a decrease with salt concentrations. On the contrary, considering a* values it was observed that the L* values were increasing with increasing salt concentration for the experiments carried on for 4 and 25°C, however, a decreasing trend in general was observed for 80°C. The measured b* values were changing quite much so that no tendency was estimated (The data were not given).

The rehydration ratio values based on the increase of weight of the soybeans are shown in Table 2. The rehydration ratio values of the soybeans were found to be in range between 2.34 and 2.89 for the experiments performed in destilled water.

Table 1: The moisture content (wet basis) values of the rehydrated soybeans

Moisture Content			
Soybean:Water Ratio / Temperature (°C)	**Salt Concentration (%)**	**1:2.5**	**1:5**
4	**0**	54.86±1.19^{axk}	60.76±1.62^{byk}
	1	54.96±1.00^{axk}	58.61±0.36^{byk}
	2	51.49±0.26$^{a(xy)k}$	58.70±2.87^{byk}
	5	47.62±1.83^{azk}	51.77±0.26^{bxk}
25	**0**	56.25±0.43^{atk}	61.17±0.76^{bzk}
	1	55.12±0.97^{azk}	59.17±0.42^{bxk}
	2	53.36±0.32^{ayk}	59.67±0.45$^{b(xy)k}$
	5	49.32±0.27$^{ax(kl)}$	60.16±0.23^{byk}
80	**0**	62.33±0.11^{ayl}	62.76±1.92^{axk}
	1	55.26±2.24^{ayk}	61.50±0.60^{bxl}
	2	56.07±1.79^{ayk}	61.46±0.57^{bxk}
	5	52.94±0.55^{axl}	60.16±0.41^{bxk}

Moisture Content			
Soybean:Water Ratio / Temperature (°C)	**Salt Concentration (%)**	**1:10**	**1:20**
4	**0**	60.41±0.07^{bzk}	60.18±0.72^{byk}
	1	59.61±0.02^{czk}	60.18±0.57^{cyk}
	2	57.34±0.58^{byk}	57.97±0.75^{byk}
	5	51.16±0.46^{bxk}	50.06±1.04^{bxk}
25	**0**	61.36±0.05^{byk}	61.88±0.56^{bxk}
	1	60.14±0.47^{bxk}	61.29±0.27^{cxk}
	2	61.00±0.39$^{c(xy)l}$	61.32±0.17^{cyl}
	5	62.45±0.14^{czk}	62.89±0.10^{dzl}
80	**0**	63.09±0.75^{axk}	63.85±0.28^{azl}
	1	63.84±0.38^{cxl}	63.28±0.25^{czl}
	2	63.28±0.34^{cxm}	62.17±0.41$^{(bc)ym}$
	5	60.11±0.40^{bxk}	61.34±0.29^{cxl}

$^{a-d}$ shows significant difference in the samples according to soybean:water ratio (P<0.05).
$^{x-t}$ shows significant difference in the samples according to salt concentration (P<0.05).
$^{k-m}$ shows significant difference in the samples according to temperature (P<0.05).

Table 2: The calculated values of rehydration ratios for soybeans

Rehydration Ratio			
Soybean:Water Ratio / Temperature (°C)	**Salt Concentration (%)**	**1:2.5**	**1:5**
4	**0**	2.34±0.07ayk	2.88±0.13byk
	1	2.31±0.06axk	2.75±0.11cyl
	2	2.27±0.08axk	2.60±0.03cyl
	5	2.34±0.10ayk	2.41±0.06bxk
25	**0**	2.35±0.16ayk	2.60±0.17(ab)yk
	1	2.58±0.12ayk	2.73±0.02azl
	2	2.18±0.15axk	2.36±0.09bxk
	5	2.42±0.12byk	2.43±0.14ayk
80	**0**	2.42±0.07axk	2.50±0.10(ab)xk
	1	2.50±0.12axk	2.48±0.16axk
	2	2.33±0.05axk	2.40±0.07bxk
	5	2.38±0.04axk	2.52±0.03bxk

Rehydration Ratio			
Soybean:Water Ratio / Temperature (°C)	**Salt Concentration (%)**	**1:10**	**1:20**
4	**0**	2.89±0.13btm	2.79±0.12byk
	1	2.67±0.03bzl	2.65±0.07byl
	2	2.58±0.05byk	2.61±0.12c(xy)k
	5	2.49±0.05cxl	2.49±0.10cxk
25	**0**	2.64±0.06(ab)zl	2.77±0.11czk
	1	2.50±0.02ayk	2.38±0.09axk
	2	2.53±0.07byk	2.54±0.15byk
	5	2.20±0.09axk	2.48±0.11cxk
80	**0**	2.50±0.06axk	2.66±0.06bxk
	1	2.50±0.11axk	2.69±0.18byl
	2	2.56±0.15dyk	2.53±0.11cxk
	5	2.86±0.03dzm	2.72±0.17cyl

[a–d] shows significant difference in the samples according to soybean water ratio (P<0.05)
[x-t] shows significant difference in the samples according to salt concentration (P<0.05)
[k-m] shows significant difference in the samples according to temperature (P<0.05)

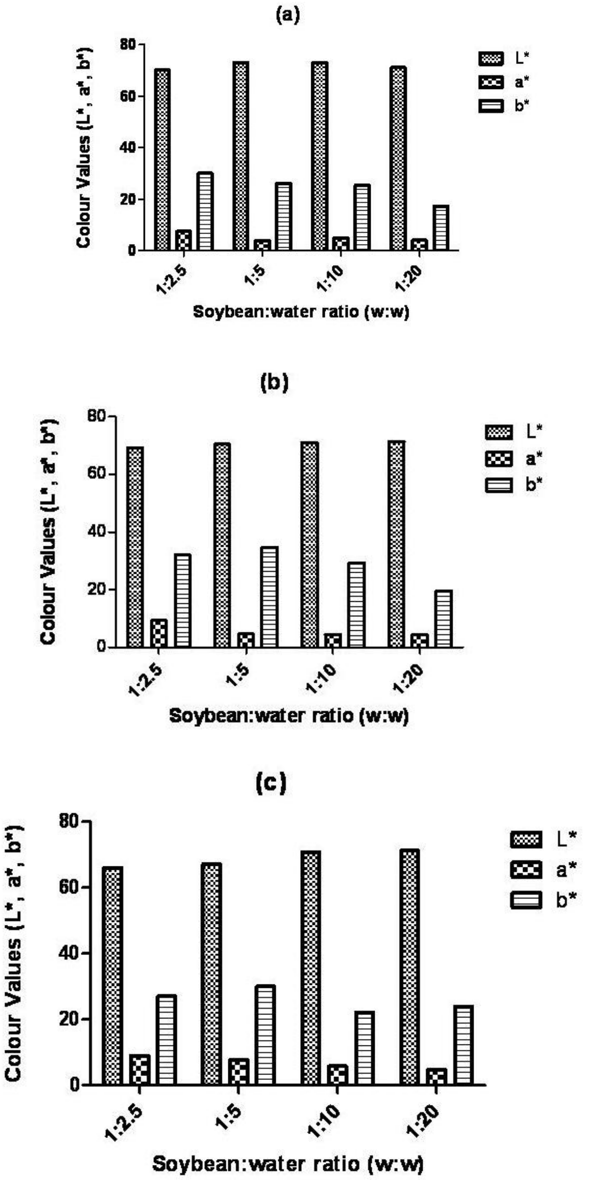

Figure 1
The colour values of rehydrated soybeans at 4°C (a), 25°C (b) and 80°C (c)

The results showed that, the rehydration ratio values of the soybeans were significantly affected by the soybean:water ratio ($P<0.05$) and higher rehydration ratio values were evaluated for 4°C soaking medium temperature. The rehydration ratio of the soybeans ranged between 2.18 and 2.86 for the experiments performed in different salt concentrations brines. The highest rehydration ratio was observed in 80°C soaking medium temperature, 5% salt concentrated, 1:10 soybean:water ratio. The results showed that, the rehydration ratio values of the soybeans were significantly affected by the salt concentrations, temperature of soaking medium and soybean:water ratio values ($P<0.05$).

The weight gain values (%) calculated based on the water absorption of the rehydrated soybeans are shown in Fig. 2. The results indicate that the weight gain occurred rapidly at the initial stage of rehydration and after a while, it started to be stationary due to filling of capillaries on the surface of the samples. After filling of the free capillaries and intercellular spaces of sample with water, water uptake started to decrease and became constant. According to Fig. 2, it was observed that the samples processed at all temperatures reached an equilibrium. The change of weight gain (%) values at 4°C and 25°C are similar in their trends, however, higher values were observed for the rehydration at 4°C. On the other hand, increasing the rehydration medium temperature to 80°C increased the rate of rehydration at the initial period and the equilibrium values attained at a very short time periods. The results showed that the weight gain values (%) observed for the soybeans soaked in brine were the same with the ones in water for the experiments at 80°C, however, significantly lower values were observed for 4 and 25°C at the end of the rehydration experiments ($P<0.05$) (The data were not given).

The results of the total soluble solid content measurements are shown in Table 3. During the soaking pretreatment of soybeans, a colour change was observed in the process water indicating soluble matter loss. While soaking pretreatment, some valuable compounds of legumes are leached out to the soaking medium and this decreasing the overall quality and desirability of the final product. The lowest total soluble solid content of rehydration medium was found in 25°C soaking medium temperature and 1:20 soybean:water ratio for the experiments at distilled water. Compared to other rehydration temperatures, higher values of TSSC of rehdyration medium was observed in 80°C soaking medium temperature for destilled water, most probably due to the structural deformation in interior structure. In general, higher values of TSSC were observed for the rehydration experiments in brine solutions. The analysis of the statistical evaluation showed that the soybean:water ratio, salt concentration of the brine, and the temperature of the soaking medium were significantly affecting the TSSC values of the samples ($P<0.05$).

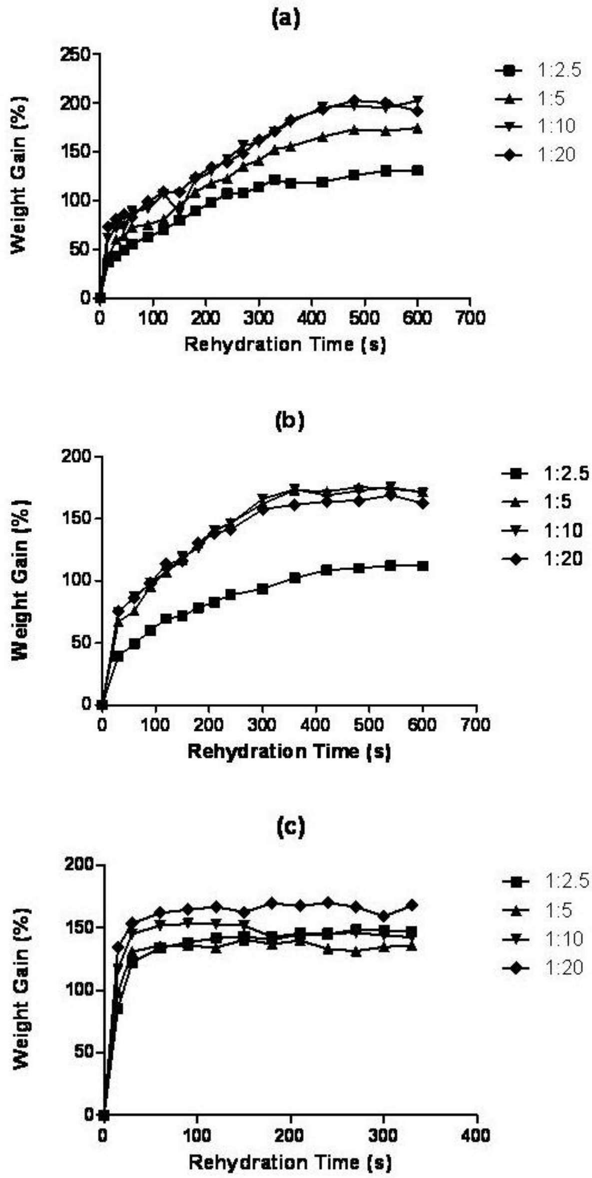

Figure 2
Weight gain (%) of rehydrated soybeans at 4°C (a), 25°C (b) and 80°C (c)

Table 3: The Total Soluble Solid Content (TSSC) (°Brix) values for rehydration medium

		Total Soluble Solid Content	
Soybean:Water Ratio / Temperature (°C)	Salt Concentration (%)	1:2.5	1:5
4	0	3.23 ± 0.26^{cxk}	2.10 ± 0.24^{bxk}
	1	4.20 ± 0.24^{cyl}	2.60 ± 0.08^{byk}
	2	5.40 ± 0.18^{czl}	3.90 ± 0.19^{bzk}
	5	8.00 ± 0.22^{ctl}	6.30 ± 0.26^{vtk}
25	0	3.13 ± 0.19^{cyk}	1.73 ± 0.12^{bxk}
	1	2.30 ± 0.13^{bxk}	2.60 ± 0.16^{cyk}
	2	4.60 ± 0.25^{dzk}	3.70 ± 0.06^{czk}
	5	7.70 ± 0.15^{dtk}	6.50 ± 0.13^{ctk}
80	0	4.83 ± 0.19^{bxl}	$3.27 \pm 0.63^{(ab)xl}$
	1	8.80 ± 0.26^{dym}	5.40 ± 0.12^{cyl}
	2	10.5 ± 0.17^{dzm}	6.50 ± 0.17^{czl}
	5	13.5 ± 0.14^{dtm}	9.40 ± 0.21^{ctl}

		Total Soluble Solid Content	
Soybean:Water Ratio / Temperature (°C)	Salt Concentration (%)	1:10	1:20
4	0	1.00 ± 0.16^{axk}	0.60 ± 0.14^{axl}
	1	2.00 ± 0.15^{ayk}	1.60 ± 0.14^{ayk}
	2	3.00 ± 0.16^{azl}	2.90 ± 0.11^{azk}
	5	6.00 ± 0.12^{btl}	5.80 ± 0.03^{atk}
25	0	1.73 ± 0.31^{bxl}	0.33 ± 0.05^{axk}
	1	2.20 ± 0.03^{byk}	1.50 ± 0.10^{ayk}
	2	3.10 ± 0.12^{bzl}	2.70 ± 0.17^{azk}
	5	6.10 ± 0.10^{btl}	5.90 ± 0.14^{atk}
80	0	$2.87 \pm 1.45^{(ab)xm}$	0.97 ± 0.17^{axl}
	1	3.30 ± 0.28^{bxl}	2.10 ± 0.11^{ayl}
	2	2.00 ± 0.21^{axk}	3.20 ± 0.13^{bzl}
	5	5.30 ± 0.25^{ayk}	6.60 ± 011^{btl}

$^{a-d}$shows significant difference in the samples according to soybean water ratio ($P<0.05$).
$^{x-t}$ shows significant difference in the samples according to salt concentration ($P<0.05$)
$^{k-m}$ shows significant difference in the samples according to temperature ($P<0.05$).

The total soluble solid content of the soaking medium was found to be proportional to salt concentration of soaking medium. In a study by Sayar et al. (2011), it was reported that the TSSC was proportional to salt concentration of soaking medium and solid loss of the chickpea samples as 2.5% at 20°C for 900 min soaking and 10.2% at 100°C for 60 min cooking where solid loss was determined by drying the whole seeds before and after the soaking treatment. In the same study it was reported that the main compounds lost to the soaking or the cooking medium are known to be carbohydrates and proteins. Therefore, the data for solid loss can be used as an indicator of the quality for soaked and/or cooked legumes.

CONCLUSION

In this study, the moisture content, colour change, rehydration behaviour of the soybeans and total soluble solid content increase in the rehydration medium were determined both in water and brine as the soaking medium. The highest moisture content value was observed for 1:20 soybean:water ratio at 80°C for water and similar values were observed at all salt concentrations for 1:10 and 1:20 soybean:water ratio values at rehydration medium temperature of 80°C. The rehydration ratio generally increased with the increase of rehydration water amount (w:w) and the highest rehydration ratio was observed for 1:10 soybean:water ratio at 4 °C. The TSSC values (°Bx) of the soaking medium were inversely proportional to amount of water and generally proportional to the soaking medium temperature. The results in general showed that 1:10 soybean:water ratio is more appropriate for the soaking pre-treatment due to efficient use of water, requirement of lower temperatures leading to energy efficiency and obtained compearable results at lower salt concentrations.

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