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Effect of *Cephalaria syriaca* addition on rheological properties of composite flour

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A b s t r a c t. The study was carried out to investigate the effect of whole and defatted *Cephalaria syriaca* flour on the rheological properties of composite flours that used in bran bread production. *Cephalaria syriaca* products were used to replace 0.25, 0.75, 1.25, 1.75, and 2.25% of wheat-wheat bran composite flour, and its rheological and fermentative properties were measured by farinograph, extensograph and rheofermentometre. The data showed that the rheological parameters of flours were greatly modified by addition of *Cephalaria syriaca*. The rheological properties of wheat-wheat bran composite flour added with whole and defatted *Cephalaria syriaca* flour were considerably improved with regard to especially extensograph characteristics such as dough resistance, area (energy), ratio number and rheofermentometer parameters such as H_m, T_1, T_x, volume loss and gas retention, as compared to control. However addition of *Cephalaria syriaca* products adversely affected the farinograph characteristics. Generally, these effects of both whole and defatted *Cephalaria syriaca* flour increased, as the addition level increased. Maximum T_x, gas retention and area (energy) of dough were obtained from wheat-wheat bran composite flour added with 1.75% whole *Cephalaria syriaca* flour, while the highest dough stability was at addition level of 0.25% whole *Cephalaria syriaca* flour.

K e y w o r d s: *Cephalaria syriaca,* wheat flour, wheat bran, dough, rheological properties

INTRODUCTION

Dietary fibre plays a very important role in the human diet and the interest in high fiber content in foods has greatly increased. For this reason, brown flours or high extraction flours are being used. Insufficient fiber consumption has been found to be associated with diseases like diverticulosis, atherosclerosis, colonic cancer and appendicitis. Different plant fibers are added to various baked food products in order to increase their fiber content. The rheological properties of dough are influenced with the quality of the flour and its finished products. The changes in flour composition might have some effect on rheological characteristics of the flours and final product quality. Wheat bran is the main fiber source for the baking industry. Despite its nutritional benefits, incorporation of fiber in baked products has been limited because of its poor functional properties. Poor extensibility, reduced loaf volume, and altered crumb structure are common problems in high-fiber baked products, because fiber disrupts the continuous viscoelastic dough matrix (Akhtar *et al*., 2009; Gajula *et al*., 2009; Masoodi *et al*., 2001; Naghavý *et al*., 2010; Sidhu *et al*., 2007).

Cephalaria syriaca is an annual weed in especially wheat fields. The growth form of *C. syriaca* is different from wheat. After a single stem reaches approximately the same height as a wheat plant, it produces four branches at sharp right angles to the main stem. The fruit is similar to a wheat grain in size and shape. *Cephalaria syriaca* is very bitter, because it contains glycosides consisting of non-toxic sugar esters. It grows in the Eastern and South-eastern of Turkey, Central Anatolia, and Eastern Mediterranean, especially Syria (Musselman, 2000).

Cephalaria syriaca grain contains 14-21% crude protein and amino acids composition is not exactly known. It contains high fat (22-28%) and has rich in linoleic acid, miristic acid, oleic acid, palmitic acid, but low linolenic acid, stearic acid, and no erusic acid. The ash and crude fibre content ranges from 3 to 10 and from 9 to 30%, respectively (Hallen *et al*., 2004; Yazıcıoğlu and Karaali, 1983). This grain is traditionally used to improve the rheological properties of dough by farmers live in some part of Turkey, but no information is available on the effect of this additive on dough rheological properties and quality of bread (Karaoğlu, 2011).

The most important property of wheat flour is its ability to form dough that retain gases and produces a baked product, particularly leavened bread with desirable eating quality. The quality of wheat flour for breadmaking is generally

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evaluated by the amount of protein and quality of gluten. However, the nonendosperm components (germ, bran and epicarp hairs) of wheat caryopsis are known to be responsible for producing the low specific volume and dense crumb structure of bran bread. Addition of bran to wheat flour negatively affects dough rheological properties and bread quality. The weakening effect of bran layer on wheat flour dough is the result of a dilution of the gluten structure by the added bran. For this reason, bran plays a prominent role in disrupting the gluten protein matrix (Bouaziz *et al*., 2010; Dervas *et al*., 1999; Indrani *et al*., 2010; Miyazaki *et al*., 2004; Pomeranz *et al*., 1977).

The aim of this research was to study the effect of *Cephalaria syriaca* flour on the rheological properties of dough from a standard bran bread formulation.

MATERIALS AND METHODS

Commercial bread wheat flour (protein: 11.51 g 100 g^{-1} flour, wet gluten: 28.51 g 100 g^{-1} flour, Zeleny sedimentation volume: 25.30 ml, falling number: 750 s., ash: 0.61 g 100 g^{-1} flour, moisture: 14 g 100 g^{-1} flour) was used for this study. Fine wheat bran was purchased from a commercial flour mill (BÝRLÝK A.Ţ. Erzurum, Turkey). *Cephalaria syriaca* seeds were obtained from a seed merchant in Erzurum, Turkey. Whole *Cephalaria syriaca* flour (WCSF) and defatted *Cephalaria syriaca* flour (DCSF) were used in bran supplemented bread formulation. Grains were milled (Quadrumat Senior Brabender laboratory mill, Duisburg, Germany) with a sieve aperture of 1 mm diameter to produce WCSF. WCSF characteristics used in the study were: protein - 14.29%, fat - 28.21%, and ash - 4.97% d.b. WCSF was freeze-dried with a freeze-dryer (Hetosicc, CD 2.5, Heto Co., Denmark) and extracted in a Soxhlet extractor with petroleum ether (60-80°C for 12 h) to produce defatted flour (DCSF). DCSF characteristics as follows: protein - 28.05% and ash - 8.16% d.b.Wheat flour (85%) plus wheat bran (15%) used in bran bread formulation was partially added with these *Cephalaria syriaca* products (CSP) at levels of 0.25, 0.75, 1.25, 1.75, and 2.25% mass. Properties of the resulting composite flours were determined.

Moisture content was determined using method 44-15A (AACC, 1995). The dough mixing properties of the different wheat *Cephalaria syriaca* flour blends were examined with the Brabender farinograph (model 8101, Brabender, Duisburg, Germany) according to method 54-21 (AACC, 2000) with minor modification. Approximately 300 g of flour (corrected to 14% moisture basis) was mixed in a 300 g mixing bowl for 12 min after development time. The following parameters were determined in the farinograph analysis: water absorption (WA, percentage of water required to yield a dough consistency of 500 Brabender units (BU)), stability (time dough consistency at 500 BU), mixing tolerance index (MTI, consistency difference between height at peak and that 5 min later), degree of softening (the difference between the line of the consistency and the medium line of the torque curve 12 min after development time), and elasticity (bandwidth of the curve at the maximum consistency, measured manually).

Extensograph characteristics of dough was determined using method 54-10 (AACC, 2000) by a Brabender extensograph model 8600 (Brabender, Duisburg, Germany). After mixing, the dough was divided into two pieces (150 g/piece) and the pieces were shaped out. They were then rested in a humidity chamber at 30°C for 45 min. Then the pieces were stretched until rupture. This procedure was also repeated for resting times of 90 and 135 min. The test result after 135 min was used for evaluation. The extensibility (*Ex*), maximum resistance (R_m), energy (area) and ratio number (BU/mm) were evaluated in an extensogram.

The rheological properties of dough during fermentation were determined using a rheofermentometer (Chopin, Tripette and Renaud Inc., France). Registered parameters: maximum dough fermentation height (*Hm*), the time at which dough attains the maximum height (T_1), loss in dough height after 3 h, the time of maximum gas formation (T^I_1), the time (min) at which gas starts to escape from the dough (T_x), and the gas retention (volume of the gas retained in the dough at the end of the assay) (Rosell *et al*., 2001).

All the experiments were carried out in triplicate and in two different trials. SPSS software for Windows (SPSS for Windows Release 10.01. SPSS Inc. Chicago, IL, USA) was used to perform statistical analyses. Differences in wheat bran bread, because of addition of *Cephalaria syriaca* products (WCSF and DCSF), were tested for significance using analysis of variance (ANOVA) techniques. Duncan new multiple range test were used when the ANOVA indicated significant difference in mean values. A level of significance of $P<0.05$ is used throughout the analysis. All data are presented as the mean ± SE.

RESULTS AND DISCUSSION

Farinograph is generally used to understand rheological behavior during dough mixing. Farinograph is a recording dough mixer that measures torque needed for mixing dough at a constant speed and temperature (Sroan and Kaur, 2004). Effect of CSP on farinograph characteristics of wheat-wheat bran (85-15%) composite flour are shown in Table 1 and Fig. 1. Farinograph studies showed that both WCSF and DCSF addition to composite flour reduced water absorption significantly, except at the addition levels of 0.25 and 1.25%. The lowest water absorption values were observed at 2.25% addition levels of both WCSF and DCSF. Water absorption is considered to be an important characteristic of wheat and composite flour and it increases with protein (gluten) content (Hoseney, 1994; Sollars and Rubenthaler, 1975). When the dough is prepared, large proportion of the

T a b l e 1. Farinograph analysis of wheat-wheat bran composite flour containing WCSF and DCSF (mean±S.E)[a]

Parameters	Addition level (%)	Water absorption (%)	Stability (min)	Mixing tolerance index (BU)	Degree of softening (BU)	Elasticity (BU)
WCSF	0	65.26±0.06abc	13.35±0.10c	4.50±0.35d	21.00±0.70c	242.50±1.75b
	0.25	65.87±0.04ab	14.20±0.07a	3.50±0.35d	10.00±0.00d	282.50±1.70a
	0.75	65.07±0.04bc	13.55±0.03c	11.00±0.70cd	5.00±0.01de	245.00±3.58b
	1.25	66.08±0.08a	14.05±0.11ab	14.50±0.35c	1.00±0.70e	250.00±0.00b
	1.75	64.42±0.37cd	14.00±0.07ab	27.50±1.70b	47.50±1.75b	252.50±1.76b
	2.25	63.67±0.13d	13.70±0.07bc	60.00±3.50a	90.00±3.50a	242.50±1.78b
GM		65.06±0.03	13.75±0.02	20.10±0.85	29.00±1.36	252.50±0.62
P		**	**	**	**	**
DCSF	0	65.26±0.06a	13.35±0.10b	4.50±0.35d	21.00±1.07e	242.50±1.76b
	0.25	65.35±0.04a	13.85±0.03a	3.50±0.36d	2.50±0.35f	257.50±1.76a
	0.75	64.56±0.20b	13.25±0.10b	12.50±1.76c	37.50±1.76d	242.50±1.78b
	1.25	65.52±0.05a	13.05±0.03bc	18.50±1.06c	95.00±0.00c	202.50±1.75d
	1.75	63.92±0.06c	13.00±0.07bc	42.50±1.75b	113.50±1.06b	212.50±1.76c
	2.25	63.46±0.15c	12.70±0.07c	82.50±1.78a	147.50±1.75a	240.00±0.00b
GM		64.68±0.03	13.25±0.01	27.30±1.21	69.50±2.28	232.90±0.83
P		**	**	**	**	**

[a] Means with different letters in the same column are statistically different at ($P<0.05$), GM – grand mean, **$P<0.01$.

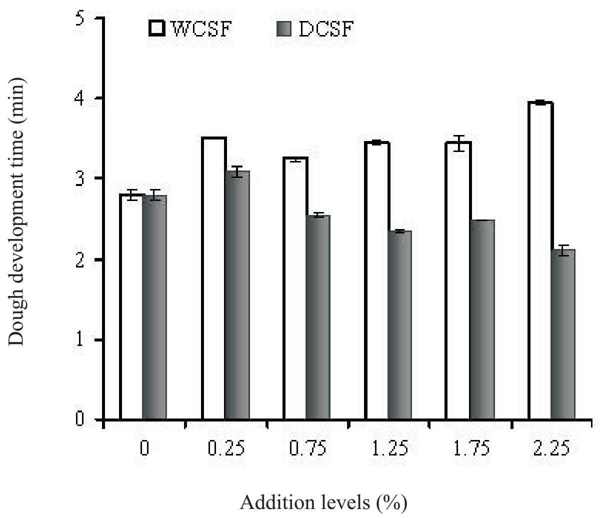

Fig. 1. Effect of WCSF and DCSF on dough development time of wheat-wheat bran composite flour.

water added to wheat flour is absorbed by gluten (Miś, 2003). For this reason, the observed lower water absorption of wheat flour blends may be attributed to the absence of gluten in CSP and the decreased hydration capacity of CSP.

Development time increased with increasing addition levels of WCSF compared to the control (Fig. 1). However, addition of DCSF to wheat-wheat barn composite flour gradually decreased development time significantly, except at the addition levels of 0.25%. Dough development time is an indication of the mixing time required for dough. The decrease in development time of composite flour added with DCSF may be associated with the decrease in water absorption values and the absence of fat.

Stability was generally increased by the WCSF addition and the greatest increase was at 0.25% WCSF level. However, addition of 1.75 and 2.25% DCSF decreased stability, significantly. Stability is an indication of the flour strength, with higher values suggesting stronger dough (Koocheki *et al*., 2009). Significant stability increase value was only observed at 0.25% addition level.

As the addition level of CSP increased, MTI was increased, except with 0.25% level which leads to a decrease. High DCSF addition level of 0.25% significantly increased degree of softening. However, degree of softening decreased until the addition level of WCSF up to 1.25% and significantly increased with high WCSF addition level of 1.25%. While elasticity of dough at 0.25% WCSF addition level was the highest, at other levels of WCSF was not significantly different from that of control dough. In general, a similar effect was observed for DCSF at the addition level of 0.25, 0.75 and 2.25%.

Composite flour with WCSF had higher water absorption, development time, stability and elasticity than that of DCSF. However, MTI and degree of softening were the highest in flour added with DCSF (Table 1). The flours added with WCSF were better with regard to farinograph characteristics than that of added with DCSF. This may be explained by an improving effect of fat in WCSF on dough rheological properties. Fats and fat-based ingredients perform both as dough stabilizer interacting with the gluten protein in the dough and as crumb softeners when the fat complexes with the gelatinizing starch during baking. The dough strengthening effect has not been completely understood. It has been suggested that emulsifiers are able to form liquid, lamellar films between the gluten and the starch, thus improving the film forming properties of the gluten (Goesaert *et al*., 2005).

In general, maximum resistance, area (energy) and ratio number of wheat-wheat bran composite flour gradually increased with increasing addition levels of CSP compared to the control, while extensibility decreased, significantly (Figs 2, 3 and Table 2). The increase in extensograph characteristics such as max resistance and ratio number were more pronounced in DCSF than WCSF. The increase of dough strength or the decrease of dough extensibility may be explained by the oxidant influence of the *Cephalaria syriaca* products (WCSF and DCSF). Formation of new disulphide bonds in the presence of an oxidizing agent would increase the strength of the dough with high resistance to extension and low extensibility. Similarly, any cleavage of disulphide bonds would result in the weakness of the dough giving low resistance and high degree of extensibility (İbanoğlu, 2002). In addition, the decrease in dough extensibility is related to decreases in the proportion of low molecular weight glutenins and some gliadins, such as α-, β-, and γ-gliadins (Shewry and Tatham, 1997). For this reason, the decrease of

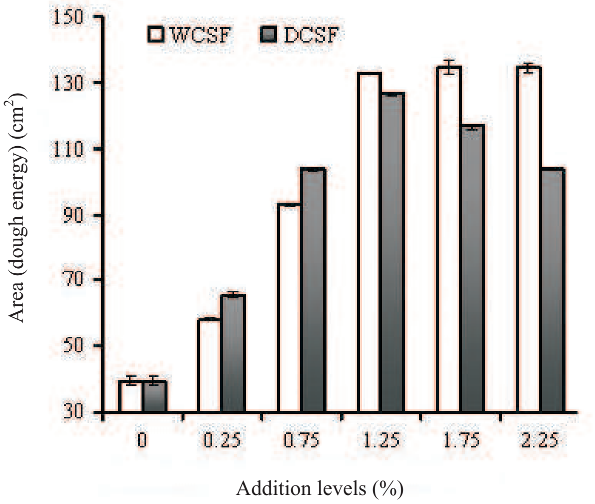

Fig. 3. Effect of WCSF and DCSF on dough energy of wheat-wheat bran composite flour.

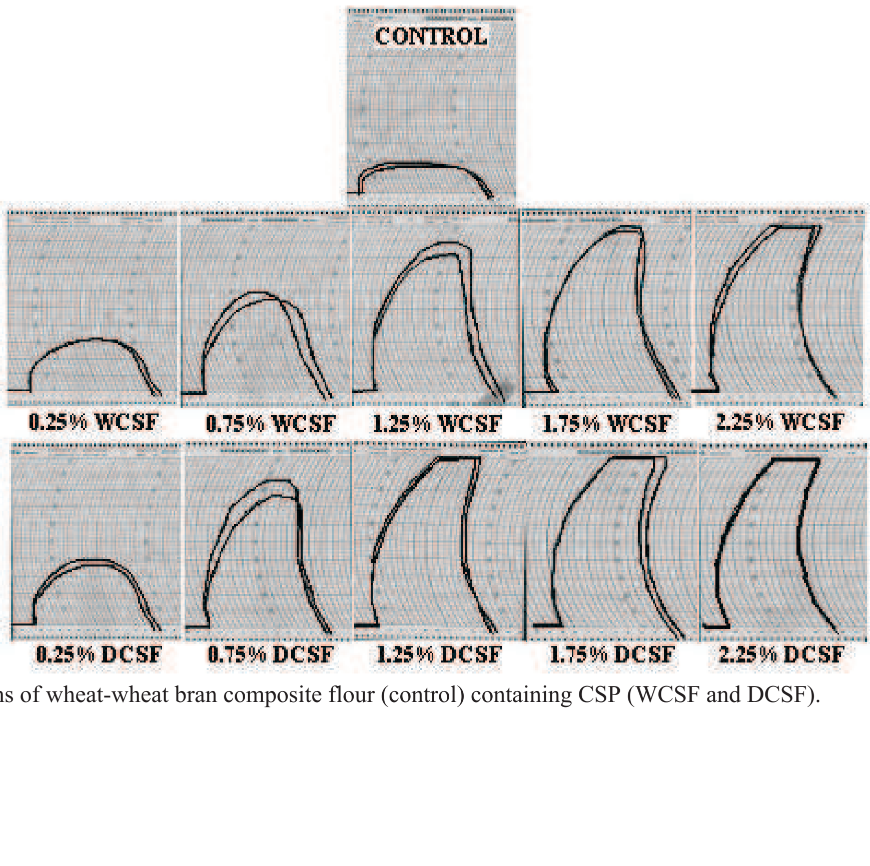

Fig. 2. Extensograms of wheat-wheat bran composite flour (control) containing CSP (WCSF and DCSF).

T a b l e 2. Effect of C*ephalaria syriaca* products on extensograph characteristics of wheat-wheat bran composite flour (mean±S.E)[a]

Parameters	Addition level (%)	Extensibility (mm)	Max resistance[b] to extension (BU)	Ratio number (BU/mm)
WCSF	0	141.10±0.07a	187.50±1.41f	1.28±0.04f
	0.25	132.50±1.76b	316.75±0.38e	2.19±0.02e
	0.75	122.50±1.75c	577.75±1.59d	4.16±0.11d
	1.25	115.00±2.12d	850.35±2.01c	6.51±0.06c
	1.75	103.50±0.35e	983.00±1.76b	8.64±0.13b
	2.25	90.00±0.00f	1000.00±0.00a	11.11±0.00a
GM		117.40±0.75	652.50±13.80	5.65±0.15
P		**	**	**
DCSF	0	141.10±0.07a	187.50±1.41d	1.28±0.04f
	0.25	126.50±0.35b	381.05±1.80c	2.57±0.00e
	0.75	113.00±0.00c	796.50±2.83b	6.27±0.20d
	1.25	96.50±1.06d	1000.00±0.00a	10.31±0.14c
	1.75	84.00±1.41e	1000.00±0.00a	11.90±0.20b
	2.25	77.50±0.35f	1000.00±0.00a	12.90±0.05a
GM		106.40±0.99	727.50±14.20	7.54±0.19
P		**	**	**

[a]Means with different letters in the same column are statistically different at (P<0.05), [b]there is no possibility to measure those traits above upper limits. Explanations as in Table 1.

dough extensibility may also be explained by the absence of gluten in the *Cephalaria syriaca* products (WCSF and DCSF). Composite flour added with WCSF had higher extensibility and area (energy) than that of DCSF. However, maximum resistance and ratio number (BU/mm) were the highest in flour added with DCSF. All these results obtained from farinograph and extensograph are similar to my previous published study (Karaoğlu, 2006) where it was investigated the effects of *Cephalaria syriaca* products on the rheological properties of medium strength wheat flour. Although bran replacement of flour disrupts the starch-gluten matrix and negatively affects dough rheological properties (Sanz Penella *et al*., 2008), the addition of *Cephalaria syriaca* have a positive effect on dough characteristics.

The evolution of dough properties throughout the fermentation can be continuously determined by the rheofermentometer, which gives information about dough development, gas production and gas retention (Wang *et al*., 2002). The influence of addition levels of WCSF and DCSF on the fermentation characteristics are shown in Table 3. Dough height (H_m) was affected in a different manner by each addition levels: It did not change significantly (P<0.05) at 1.75% addition levels as compared with the control, 0.75% addition level of both WCSF and DCSF significantly increased it. Conversely, 0.25, 1.25 and 2.25% addition levels of DCSF yielded a pronounced decrease of the dough height, which was in agreement with the extensibility decrease measured by extensograph. In general, composite flour supplemented with WCSF had higher dough heights (H_m) than that of DCSF.

The time of maximum dough development (T_1) was increased by the addition of WCSF except 0.25% addition level. However, DCSF had not significant effect on the time of maximum dough development. Loss in dough volume expressed as percentage was significantly reduced by addition of CSP when compared to the control sample (Table 3). Moreover, there was not occurred a volume loss in composite flour added with 0.75, 1.25, 1.75, 2.25% WCSF and 1.25%, 1.75 DCSF. Since volume loss is related to dough stability, these results indicate that CSP improve dough stability during fermentation, and in consequence, longer fermentation might be possible. Therefore, CSP are also additives with enormous perspectives to use in processes which necessitate both slower and longer fermentation period.

Addition of 0.75 and 1.75% WCSF significantly increased T_x (the time at which gas stars to escape from dough) while DCSF had not significant (P<0.05) effect on T_x. In general, T'_1 (the time of maximum gas formation) was decreased by CSP addition (Table 3) while gas retention (%) was increased (Fig. 4). And this indicates that the addition of CSP decreased dough permeability in terms of carbon dioxide. The addition of particular components, especially bran and outer layer fibres, to dough promotes a physical disruption

T a b l e 3. Effect of *Cephalaria syriaca* products on rheofermentometer of wheat-wheat bran composite flour (mean±S.E)[a]

Parameters	Addition level (%)	H_m (mm)	T_1 (min)	Loss (% vol.)	T_x (min)	T'_1 (min)
WCSF	0	14.60±0.07c	170.00±5.65ab	3.45±0.03a	47.50±1.71c	150.00±1.41a
	0.25	15.35±0.10b	158.00±4.85b	2.60±0.00b	41.00±0.70d	57.00±5.65c
	0.75	23.00±0.07a	180.00±0.00a	0.00±0.00c	55.00±0.71b	125.00±0.70b
	1.25	15.55±0.18b	180.00±0.00a	0.00±0.00c	52.00±2.12bc	130.00±0.71b
	1.75	14.45±0.24c	180.00±0.00a	0.00±0.00c	63.00±0.00a	146.50±1.06a
	2.25	15.90±0.07b	180.00±0.00a	0.00±0.00c	47.50±1.11c	124.00±0.70b
GM		16.47±0.13	174.66±0.41	1.00±0.06	51.00±0.31	122.08±1.35
P		**	*	**	**	**
DCSF	0	14.60±0.07b	170.00±5.65a	3.45±0.03a	47.50±1.71a	150.00±1.41a
	0.25	13.30±0.35c	179.00±0.70a	0.75±0.03d	50.00±1.41a	123.50±1.76b
	0.75	16.50±0.14a	179.00±0.71a	1.25±0.03c	49.50±3.18a	59.00±3.53c
	1.25	12.75±0.24c	180.00±0.00a	0.00±0.00e	53.00±0.70a	154.00±0.71a
	1.75	15.00±0.07b	180.00±0.00a	0.00±0.00e	43.50±0.35a	127.00±0.70b
	2.25	12.65±0.10c	176.50±1.06a	1.65±0.03b	53.00±0.71a	149.00±1.41a
GM		14.13±0.06	177.41±0.21	1.18±0.09	49.41±0.17	127.08±1.42
P		**	-	**	-	**

Explanations as in Table 1.

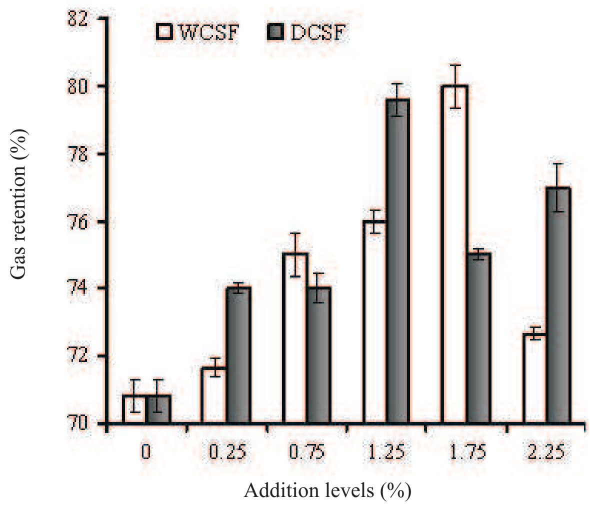

Fig. 4. Effect of WCSF and DCSF on gas retention of dough obtained from wheat-wheat bran composite flour.

of the gluten matrix. Fibres act as points of weakness or stress concentrations within the expanding dough cell walls (Kock *et al*., 1999; Wang *et al*., 2002). These results support the use of CSP as improver of gas retention during the fermentation in composite flour systems including bran.

CONCLUSIONS

1. The addition of *Cephalaria syriaca* products (WCSF and DCSF) to bran supplemented flour used in bran bread production significantly modifies the rheological properties of the dough and improves the breadmaking quality. Positive effects were observed in the extensograph and rheofermentometer characteristics by addition of *Cephalaria syriaca* products than farinograph characteristics. In this sense, it could be concluded that a longer period is needed to in order that *Cephalaria syriaca* products can be effective on dough rheological properties. In that, extensograph and rheofermentometer procedure is completed at longer period (135 and 180 min, respectively) than farinograph (about 15 min).

2. Increased levels of WCSF and DCSF, adversely affected the water absorption, stability, softening degree and mixing tolerance index to an in less extend WCSF than DCSF. Addition of both WCSF and especially DCSF most significantly increased dough strength and decreased dough extensibility. At 1.25% level, the addition of WCSF and DCSF increased maximum resistance to extension of dough from about 187 BU to 850 BU and 1000 BU, respectively.

3. Rheofermentometer parameters: H_m, volume loss, T_x and gas retention, were also positively affected by addition of both WCSF and DCSF.

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