PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 10 (4): 302-306, 2011
ISSN 1680-5194

Rheological Properties of Wheat Flour Dough as Affected by Addition of Whey and Soy Proteins

Abdalla S. Ammar, Samir A. Salem and Farid H. Badr
Department of Food Science and Human Nutrition,
College of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia

Abstract: Dairy by-products and soy proteins are considered natural functional additives having the ability to interact with the starch and gluten network in a dough system. The effects of whey protein (i.e., acid whey, sweet whey, retentate of whey by Reverse Osmosis (R.O), the permeate, pasteurized acid whey, pasteurized sweet whey and whey protein concentrate)and soy protein (raw soy milk, sterilized soy milk, soy protein isolate) addition on dough rheology were studied using Farinograph. The addition of whey protein concentrated by R.O (retentate) exhibited the highest ability to increase water absorption, dough stability, dough development time and time to breakdown of the dough (72.8%, 8.7, 7.7 and 10.0 min, respectively) followed by pasteurized sweet whey and whey protein concentrate. Also, the effect of added raw soy milk was the best on the studied rheological properties (63.2%, 10.3, 6.7, 10.8 min, respectively) of the dough.

Key words: Rheological properties, wheat flour dough, cheese whey, soy protein, soy milk, farinograph

INTRODUCTION

Bakery products in the middle east especially in the Arab countries consider an important source of nutrients i.e., energy, protein, minerals and vitamins. Most bakery products can easily be enriched and fortified at low cost with proteins, vitamins and minerals to meet specific needs of the target groups of the population (Indrani *et al.*, 2007). Whey is a byproduct of the cheese industry. Approximately, 9 kg of whey is produced for every kilogram of cheese manufactured. The high Chemical Oxygen Demand (COD) (50 kg O_2/ton permeate) of whey makes its disposal a significant pollution problem. In order to minimize environmental impacts different uses for this waste material have been devised by the dairy industry (Martin-Diana *et al.*, 2006). In recent years, utilization of whey has been felt to be an inexorable necessity in view of the current requirements for alleviating environmental pollution as well as using available nutrients for feeding the malnourished segments of human population. Whey can be incorporated advantageously into various food formulation (Mathur and Shahani, 1979). Whey Permeate (WP) is obtained as a by-product when whey proteins are concentrated by ultrafiltration to produce whey protein concentrate (Martin-Diana *et al.*, 2006). Also, soy bean contains the highest quality and quantity protein of any other plant sources (Smith and Circle, 1972) and is an inexpensive source of protein and calories for human consumption and in addition, it is seen as a low cost substitute for dairy milk for poor in developing countries. Being free of cholesterol, gluten and lactose, soy milk is also a suitable food for lactose-intolerant consumers, vegetarians and milk-allergy patients (Chou and Hou, 2000). The usage of soy bean proteins in human foods is increasing and can be expected to increase as food technology develops organoleptically acceptable products for the consumer (Wolf and Cowan, 1977). The use of isolated soy protein is increasing because of its functional properties and as an economical source of dietary protein (Steinke *et al.*, 1980). On the other hand, due to increment using mechanization in baking industry, demand for strong wheat flours, yielding doughs with high tolerance to handling and mixing and stable during fermentation was increased (Caballero *et al.*, 2007a). For adjusting the variations in flour properties and baking conditions, chemical improvers have been used, also to increasing the nutritional value and functional properties of bakery products some studies were investigated to add enzymes (Caballero *et al.*, 2007b), whey protein concentrate (Indrani *et al.*, 2007; Asghar *et al.*, 2009) and soy isoflavones and soy protein isolate (Shao *et al.*, 2009). Rheological properties of dough can be used as quality indicators for cereal products (Asghar *et al.*, 2009). This fact has contributed to use rheological testing for following the changes in dough systems and mechanical properties. There is a lack information on the addition of dairy by-products such as acid whey, sweet whey and soy milk comparable with whey protein concentrate and soy protein isolate to bakery products. Thus, the objective of this study was to determine the rheological characteristics of wheat flour (72% extraction) dough which use the different sorts of whey with different technological treatments and soy milk comparable with whey protein concentrate and soy protein isolate.

Corresponding Author: Abdalla S. Ammar, Department of Food Science and Human Nutrition, College of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia

MATERIALS AND METHODS

Wheat flour (72% extraction) was purchased from local market, Saudi Arabia. Dry local whole soy beans were obtained from Egypt (Agricultural Research Center). Whey Protein Concentrate (WPC) and Soy Protein Isolate (SPI) were purchased from Agrimark, USA.

Acid whey: Obtained by coagulating the pasteurized cow milk by lactic acid bacteria to reach pH 4.6, then drained the whey by using clothes filtration.

Sweet whey: Collected from coagulation the pasteurized cow milk by calf rennet after addition of 0.02% $CaCl_2$ for 30 min and filtrated by clothes after cutting the curd.

Reverse osmosis of whey: Sweet whey was concentrated to 2-fold by reverse osmosis unit (model: Armfield FT18, England). Permeate of reverse osmosis whey obtained after R.O operation as the waste of product.

Soy milk: Prepared according to Salem (1984) as follows: dry local whole soy beans (care was taken to ensure that good quality and mold free soy beans were selected) were washed and blanched for 30 min in 0.25% sodium bicarbonate solution (1:5 beans: water) at 100°C. The beans were washed and soaked in water at room temperature (20±5°C) over night, then dehulleded beans manually, washed and ground in warring blender for 5 min with previously, boiled water. The ratio of beans to water was 1:3 (w/v) and the temperature of water during grinding between 50-60°C. the resulted suspension was filtered by centrifugation at 3000 rpm for 3 min. The soy milk was autoclaved for 15 min at 121°C and held at 5°C until used.

Rheological characteristics: Rheological characteristics measurements for wheat flour with addition of each raw acidic whey, raw sweet whey or pasteurized whey, reverse osmosis whey treated, permeate reverse osmosis of whey, raw soy milk or sterilized, Whey Protein Concentrate (WPC) and Soy Protein Isolate (SPI) were studied using Farinograph-E (Brabender GmbH & Co. KG, Duisburg, Germany), according to standard AACC methods (2000) at 0.7% protein. The parameters determined were % water absorption, Dough Development Time (DDT), dough stability and time to breakdown. Wheat flour alone was used as control.

Chemical analyses: Whey were analyzed for total protein, fat and Total Solids (TS) according to Standard Methods for the Examination of Dairy (APHA, 1978). The pH values for whey and soy milk were measured using a pH meter (Hanna, Romania). The soy protein and soy milk were analyzed for protein content using Kjeldahl method using factor 6.25 and total solids according to AOAC (1975). Fat content of soy protein and soy milk determined according to the method described by Pricpke *et al.* (1980).

RESULTS AND DISCUSSION

The proximate composition: Raw additives i.e., acidic whey, sweet whey, whey protein concentrate, raw soy milk, sterilized soy milk and soy protein isolate were chemically analyzed. The data in Table 1 indicated that the sweet whey and acidic whey contained 0.63-0.70% total protein, 0.5% fat, 8.6-9.8% TDS, 6.2-6.5% TS and pH 6.5-4.6, respectively. Also, raw soy milk and sterilized soy milk contained 2.40-2.36% total protein, 2.5% fat, 5.3-6.1% TDS, 8.0-8.2% TS and pH 7.10-7.36, respectively. It can be noticed that the highest content of total protein and fat for soy products comparing with the other whey by-products.

Effect of added whey proteins on dough rheology properties: The Farinograph water absorption, dough stability time, dough development time and time to breakdown for the used wheat flour (control) were 64.3%, 14.1 min, 7.3 min and 17.1 min, respectively (Table 2).

The effects of whey protein (i.e., acid whey, sweet whey, retentate of whey by R.O, the permeate, pasteurized acid whey, pasteurized sweet whey and whey protein concentrate) addition on dough rheology were summarized in Table 2. Comparing to control, water absorption was increased by addition of whey protein as a function of increase protein percent in the dough. This effect was more pronounced in the addition of whey protein concentrated by R.O (retentate) where as the increase in water absorption was up to 8%. Since, it is known that most whey proteins are water soluble but gluten, wheat dough protein, is mostly water insoluble (Anton *et al.*, 2008), the higher water absorption of the blends could be related to the high water absorption of the whey protein.

Dough Stability (DS) is given by the time from when the Farinograph trace touches the 500 BU line up to the break time. Dough stability decreased when whey proteins were added (Fig. 1). This is logical since whey protein effect on wheat dough viscoelastic properties. Therefore, by the addition of whey protein the dough rheological characteristics are negatively affected. Zadow (1981) reported that addition of WPC in the preparation of the bread resulted in a weaker and less elastic dough. He further opined that the weakening of the wheat flour dough is duo to interference of WPC sulphydryl groups in the normal sulphydryl/disulphide interchange reactions occurring during wheat flour dough development.

The time required for dough development or time necessary to reach 500 BU of dough consistency (DDT) slightly decreased by the addition of whey protein. While, the addition of R.O permeate more decreased DDT (2.4 min) this may be due to the increasing of lactose content. Dough mixing (DDT) studies showed that the addition of whey protein impacted the time the dough maintain its best consistency at the 500 BU line.

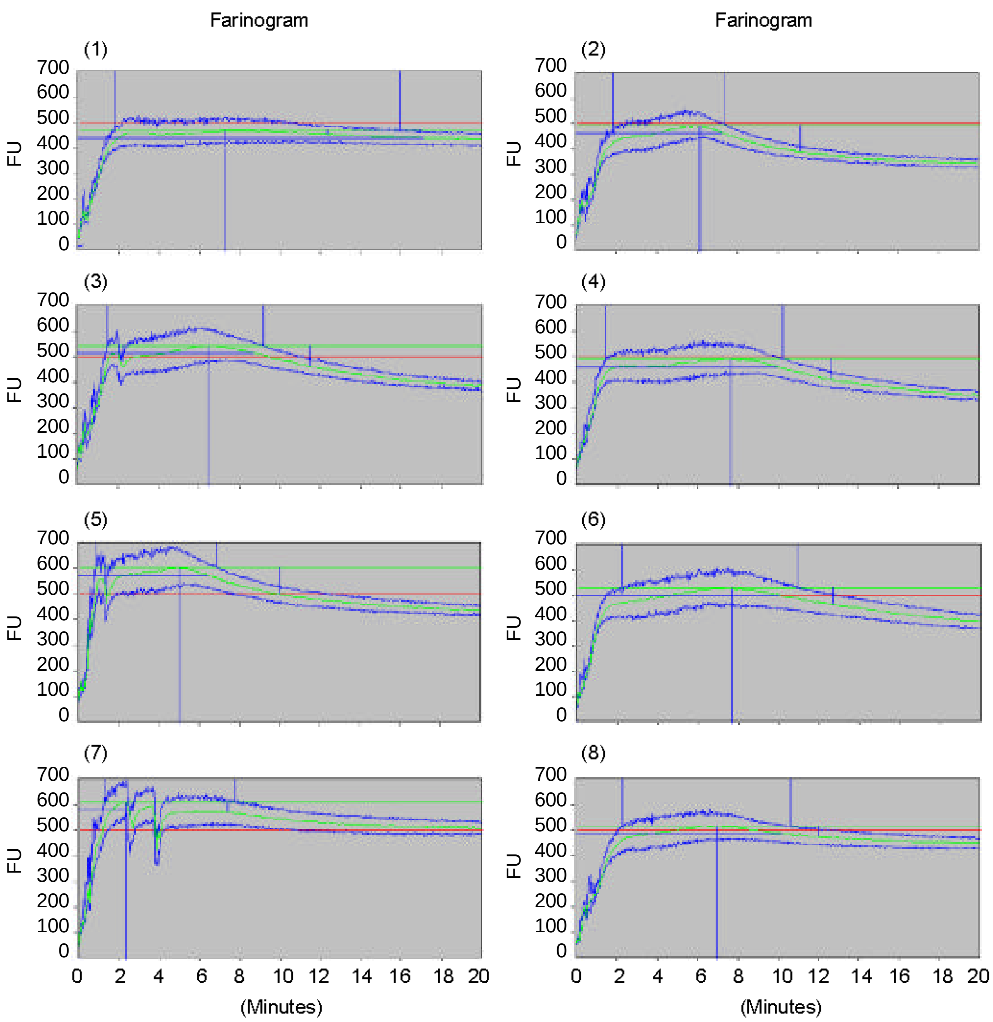
Table 1: Proximate composition of raw additives

Raw materials	Total protein (%)	Fat (%)	TDS (%)	TS (%)	pH
Acidic whey from coagulation	0.70	0.50	9.80	6.50	4.60
Sweet whey from coagulation	0.63	0.50	8.60	6.20	6.50
Whey protein concentrate	80.00	5.00	-	95.00	-
Raw soy milk	2.40	2.50	5.30	8.20	7.36
Sterilized soy milk	2.36	2.50	6.10	8.00	7.10
Soy protein isolate	90.00	-	-	95.00	-
RO whey protein	1.30	1.00	11.50	-	-
Permeate of whey	0.00	0.00	1.00	-	-

Table 2: Effect of added whey proteins on dough rheology properties

Flour blends	Conc. (%)	WA (%)	DS (min)	DDT (min)	TBD (min)
Control*	100.0	64.3	14.1	7.3	17.1
Control + acidic whey	0.7	65.9	5.6	6.2	7.3
Control + sweet whey	0.7	66.2	7.7	6.5	8.7
Control + RO whey	0.7	72.8	8.7	7.7	10.0
Control + permeate of whey	0.7	67.8	6.5	2.4	2.5
Control + pasteurized acidic whey	0.7	67.6	6.0	5.0	6.4
Control + pasteurized sweet whey	0.7	64.8	8.9	7.7	10.0
Control + whey protein concentrate	0.7	65.4	8.3	7.0	10.3

*Control: Wheat flour (72% extraction), WA: Water Absorption, DS: Dough Stability, DDT: Dough Development Time, TBD: Time to Breakdown



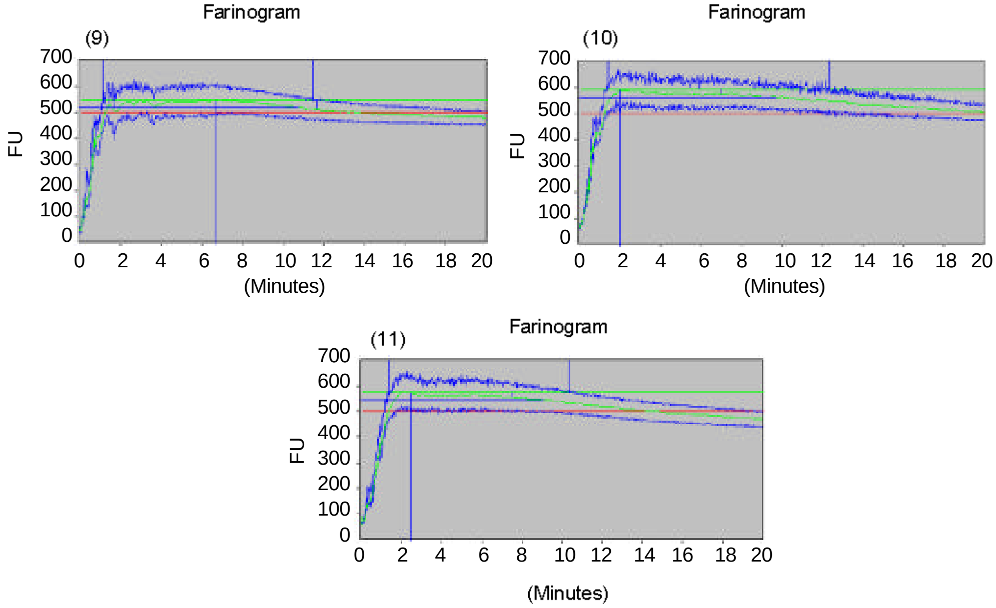


Fig. 1: The farinograms of the different blends of wheat flour and whey or soy proteins. 1: Control (wheat flour), 2: Acidic whey, 3: Sweet whey, 4: Pasteurized sweet whey, 5: Pasteurized acidic whey, 6: RO whey, 7: Permeate of whey, 8: Whey protein concentrate, 9: Raw soy milk, 10: Sterilized soy milk and 11: Soy protein isolate

Table 3: Effect of added soy milk before and after sterilization and soy protein isolate on dough rheology properties

Flour blends	Conc. (%)	WA (%)	DS (min)	DDT (min)	TBD (min)
Control*	100.0	64.3	14.1	7.3	17.1
Control + raw soy milk	0.7	63.2	10.3	6.7	10.8
Control + sterilized soy milk	0.7	67.3	10.9	2.0	9.8
Control + soy protein isolate	0.7	66.9	9.0	2.5	9.1

*Control: Wheat flour (72% extraction), WA: Water Absorption, DS: Dough Stability, DDT: Dough Development Time, TBD: Time to Breakdown

Time to breakdown is shown by the drop of the Faringraph curve from the 500 BU line. Dough time to breakdown decreased when whey proteins were added. This was more noted when permeate whey protein added (Fig. 1).

Effect of added soy proteins on dough rheology properties: The effect of soy proteins (i.e., raw soy milk, sterilized soy milk, soy protein isolate) addition on dough rheology is shown in Table 3. The amount of absorbed water required to centre the Farinograph curve on the 500 BU line increased with addition of soy proteins. This effect was more observed in case of the addition of soy protein isolate where the increase in water absorption was up to 3%.
Comparing to control, the addition of soy proteins impacted the dough stability, dough mixing and dough weakening times (Table 3). Lorimer *et al.* (1991) noticed that the addition of non-gluten forming proteins (e.g. legume proteins) causes a dilution effect and consequent weakening of wheat dough. They suggested several factors that cause weakening, namely, competition between the legume proteins and gluten for water molecules, the disruption of starch-protein complexes by the foreign proteins and disruption of SS interchange by the non gluten proteins.

Conclusion: From the above results it could be concluded that the addition of whey protein concentrated by R.O (retentate), pasteurized sweet whey, whey protein concentrate and raw soy milk led to improve rheological properties of dough which have a beneficial effect as improver agents and functional ingredients in bakery products processing.

REFERENCES

AACC, 2000. Approved methods of the American Association of Cereal Chemists. St. Paul. Minnesota: The Amer. Assoc. Cereal Chem. Inc.

AOAC, 1975. Official Methods of Analysis. 12th Edn., W. Horwitz- Assn. Off. Anal. Chem., Washington, DC.

Anton, A.A., K.A. Ross, O.M.R. Lukow, Gary Fulcher and S.D. Arntfield, 2008. Influence of added bean flour (*Phaseolus vulgaris* L.) on some physical and nutritional properties of wheat Flour tortillas. Food Chem., 109: 33-41.

APHA, 1978. American Public Health Association, Standard methods for the examination of dairy products. 14th Edn., Washington, DC.

Asghar, A., F.M. Anjum, J.C. Allen, C.R. Daubert and G. Rasool, 2009. Effect of modified whey protein concentrates on empirical and fundamental dynamic mechanical properties of frozen dough. Food Hydrocolloids, 23: 1687-1692.

Caballero, P.A., M. Go´mez and C.M. Rosell, 2007a. Bread quality and dough rheology of enzyme-supplemented wheat flour. Eur. Food Res. Technol., 224: 525-534.

Caballero, P.A., M. Go´mez and C.M. Rosell, 2007b. Improvement of dough rheology, bread quality and bread shelf-life by enzymes combination. J. Food Eng., 81: 42-53.

Chou, C.C. and J.W. Hou, 2000. Growth of bifidobacteria in soy milk and their survival in the fermented soy milk drink during storage. Int. J. Food Microbiol., 56: 113-121.

Indrani, D., P. Prabhasankar, J. Rajiv and G. Venkateswara Rao, 2007. Influences of whey protein concentrate on the rheological characteristics of dough, microstructure and quality of unleavened flat bread (parotta). Food Res. Int., 40: 1254-1260.

Lorimer, N., J.B. ZabikHarte, N.C. Sitchiw and M.A. Uebersax, 1991. Effect of Navy bean protein flour and bean globulins on composite flour rheology, chemical bonding and microstructure. Cereal Chem., 68: 213-220.

Martin-Diana, A.B., D. Rico, J. Frias, J. Mulcahy, G.T.M. Henehan and C. Barry-Ryan, 2006. Whey permeate as a bio-preservative for shelf life maintenance of fresh-cut vegetables. Innovative Food Sci. Emerging Technol., 7: 112-123.

Mathur, B.N. and K.M. Shahani, 1979. Use of total whey constitutes for human food. J. Dairy Sci., 62: 99.

Pricpke, P.E., L.S. Wei, A.I. Nelson and M.P. Steinberg, 1980. Suspension stability of ILLIONIS soybean beverage. J. Food Sci., 45: 242-245.

Salem, S.A., 1984. Utilization of some oily seed proteins in some Simulated products. Ph.D. Thesis, Galati University, Romania.

Shao, S., A.M. Duncanb, R. Yanga, M.F. Marconec, I. Rajcand and R. Tsao, 2009. Tracking isoflavones: From soybean to soy flour, soy protein isolates to functional soy bread. J. Functional Foods, 1: 119-127.

Smith, A.K. and J.J. Circle, 1972. Soy beans: Chemistry and Technology. AVI Publishing Co., Westport, Conn.

Steinke, F.H., E.E. Preacher and D.T. Hopkins, 1980. Nutritional Evaluation (PER) of isolated soybean protein and combinations of food proteins. J. Food Sci., 45: 323-327.

Wolf and Cowan, 1977. Soybean as a food source. C.R.C. Prees, Inc. Granwood Pavkwsy Cleveland-Ohio.

Zadow, J.G., 1981. Measurement of the effect of whey protein concentrates on fermenting dough by the Instron Tester. Aust. J. Dairy Technol., 36: 56-59.