STUDIES ON CAKE QUALITY MADE OF WHEAT-CHICKPEA FLOUR BLENDS

Manuel Gómez[1,*], Bonastre Oliete[1], Cristina M. Rosell[2], Valentín Pando[3], Encarnación Fernández[1]

[1] Departamento de Ingeniería Agrícola y Forestal, Tecnología de los Alimentos, E.T.S.Ingenierías Agrarias, Universidad de Valladolid, 34004 Palencia, Spain.

[2] Cereals Group, Instituto de Agroquímica y Tecnología de Alimentos, CSIC, P.O. Box 73, 46100 Burjassot, Valencia, Spain.

[3] Departamento de Estadística e Investigación Operativa, E.T.S. Ingenierías Agrarias, Universidad de Valladolid, 34004 Palencia, Spain.

*To whom correspondence should be addressed. E-mail: pallares@iaf.uva.es.
Phone number: +34979108359
Fax number: +34979108302

Abstract

Legume flours, due to their amino acid composition and fibre content are ideal ingredients for improving the nutritional value of bread and bakery products. In this study the influence of the total or partial replacement of wheat flour by chickpea flour on the quality characteristics of two kinds of cake was analyzed. The effects of the chickpea variety and the milling system were also considered. Volume, symmetry, chroma, and crust and crumb L* diminished when increasing the amount of chickpea flour. The replacement of wheat flour by chickpea flour also induced an increase in the initial firmness but cohesiveness and resilience diminished, increasing the tendency to hardening. The chickpea variety and the milling process (white or whole flour) had also significant influence on cake quality.

Key words: composite flours, chickpea, cake quality, texture properties, staling.

1. Introduction

Pulses have been at the heart of many traditional cuisines for thousands of years. Legumes have been known as “a poor man’s meat”. They supply protein, complex carbohydrates, fibre and essential vitamins and minerals to the diet, are low in fat and sodium and contain no cholesterol. Legumes have been identified as low glycaemic index foods (Bornet, Billaux & Messing, 1997). Selecting foods of low glycaemic index is very important in the dietary treatment of diabetes mellitus, increases satiety, facilitates the control of food intake and has other health benefits for healthy subjects in terms of post-prandial glucose and lipid metabolism (Rizkalla, Bellisle & Slama, 2002). Regular consumption of pulses may have important protective effects on risk for cardiovascular disease (Anderson & Major, 2002). Moreover, pulses contain a rich variety of compounds, which, if consumed in sufficient quantities, may help to reduce tumour risk (Mathers, 2002). In fact, most health organizations encourage their frequent consumption (Leterme, 2002). These nutritional benefits are related to the reduced digestibility of legume starch and dietary fibre content of legumes, mainly located in their husk fractions. The low digestibility of legume starch has been attributed to its amylose, which is considerably branched and of high molecular weight (Tharanathan & Mahadevamma, 2003).

In the last decades, attitudes and perceptions towards legumes have been changing, bringing about a revival of interest on the part of consumers (Morrow, 1991). The annual per capita consumption of pulses in 1999 was 5.9 kg worldwide, and 2.8 kg in Europe. These consumption figures rose by 10% from 1989 to 1999 but they could increase even further if the food industry and professional organizations take up the challenge to incorporate grain legumes in novel, convenient and healthy food products (Schneider, 2002). The addition of legume to cereal-based products could be a good alternative for increasing the intake of legumes. In addition, legume proteins are rich in lysine and deficient in sulphur containing amino acids, whereas cereal proteins are deficient in lysine, but have adequate amounts of sulphur amino acids (Eggum & Beame, 1983). Therefore, the combination of grain with legume proteins would provide better overall essential amino acid balance, helping to combat the world protein calorie malnutrition problem (Livingstone, Feng & Malleshi, 1993).

Several studies about the influence of the addition of legume flours on the functional properties of bread dough and final bread quality have been reported in the last 30 years. Among the legumes tested, it is worth mentioning the addition of chickpea flour (Singh, Harinder, Sekhon & Kaur, 1991; Dodok, Ali, Hozová, Halasová & Polacek, 1993; Iyer & Singh, 1997), germinated chickpea flour (Fernandez & Berry, 1989), germinated pea flour (Sadowska, Blaszczak, Fornal, Vidal-Valverde & Frias, 2003), lupin flour (Campos & El-Dash, 1978; Lucisano & Pompei, 1981; Dervas, Doxastakisk, Hadjisavva-Zinoviadi, & Triantafillakos, 1999; Doxastakis, Zafiriadis, Irakli, & Tananaki, 2002; Pollard, Stoddard, Popineau, Wrigley & MacRitchie, 2002), fermented lentil flour (Sadowska, Fornal, Vidal-Valverde & Frias, 1999), lentil and bean flours (Finney, Morad & Hubbard, 1980; Morad, Leung, Hsu & Finney, 1980; Shehata, Darwish, El-Nahry & Andel-Razek, 1988; Lorimer, Zabik, Harte, Stachiw & Uebersax, 1991) to wheat flour for obtaining bread. However, despite the good results obtained with bread, those studies have not been extended to other cereal baked products.

The aim of this study was to determine the effect of the partial or complete replacement of wheat flour by chickpea flour on the quality of cakes. The effect of the chickpea variety and the milling process was also tested.

2. Materials and methods

2.1 Materials

Cake flour (9.8% protein) was supplied by *Harinera Castellana* S.A., Medina del Campo (Spain); sucrose, sunflower oil, milk, fresh whole eggs, emulsifier and double-action baking powder, were purchased from the local market.
Chickpeas were supplied by Alimentos Naturales S.A., León (Spain) and milled in a stone mill in Harinera Los Pisones, Zamora (Spain). After milling, the flour with particle size lower than 210 μm was referred as white chickpea flour; and the coarse fraction was ground again in a laboratory mill (3100, Perten Instruments, Sweden). The flour from the second milling was blended with the white chickpea flour in order to obtain the whole chickpea flour.

2.2 Proximate analysis of flours

Wheat and chickpea flours were analysed following the AACC methods (2000) for moisture (method 44-15A), crude protein (method 46-13), crude fat (method 30-25), crude fiber (method 32-10) and ash (method 08-01).

2.3 Pasting properties of flours

The Rapid ViscoTM Analyser (RVA) (Newport Scientific Pty Ltd, Australia) was used to determine the pasting properties of the chickpea flours. Pasting properties were determined following the standard Newport Scientific Method 1 (STD1). The heating cycle was 50 ºC to 95 ºC in 282 s, holding at 95 ºC for 150 s and then cooling to 50 ºC. Each cycle was initiated by a 10-second mixing at 960 rpm paddle speed, and 160 rpm paddle speed was used for the rest of the test. The RVA studies were carried out using 3.0 g of sample and 25 ml water in an aluminium canister. The parameters recorded were peak viscosity (PV), trough or hot paste viscosity (HPV), final or cool paste viscosity (CPV), breakdown (PV-HPV), and setback (CPV-HPV). Flour samples were run in triplicate.

2.4 Cake preparation

Two kinds of cakes were elaborated: a layer cake (Cake A), and a sponge cake (Cake B). The recipes used are described in Table 1. In layer cake elaboration, a single-bowl mixing procedure was used. All ingredients were mixed during 10 min at speed 6 using a Kitchen–Aid Professional mixer (KPM5). 200 grams of cake batter were placed into 120 mm diameter and 45 mm height, metallic, lard coated pan, and were baked in an electric oven for 25 min at 200ºC.

In the sponge cake making, a creaming mixing procedure was used. All ingredients, except for the flour and milk, were mixed during 2 min at speed 6 using a Kitchen–Aid Professional mixer (KPM5). After the addition of the milk and the flour, the mixing process continued during 3 min at speed 8. 150 grams of cake batter were placed into pans and baked as described above.

Two sets of twelve cakes were prepared from each batter. After baking, the cakes were removed from the pans and left one hour for cooling; then, they were placed on coded white plastic plates, and sealed with plastic wraps to prevent drying. Eight cakes from the same batter were used for physical measurements, and four for texture evaluation after seven and 14 days of storage.

2.5 Physical Measurements

Batter density was determined with a measuring cylinder and expressed as the relation between the weight of batter and the same volume of distilled water.

Cake quality attributes included: volume, determined by seed displacement, weight, symmetry and volume index, measured following the AACC method 10 – 91 (AACC, 2000). A digital calibre was used to measure the cake heights. Measurements were run in triplicate.

Colour was measured using a Minolta spectrophotometer CN-508i (Minolta, Co.LTD, Japan). Results were expressed in the CIE L*a*b* colour space and were obtained using the D65 standard illuminant, and the 2º standard observer. The hue angle ($\tan^{-1}(b^*/a^*)$) and chroma or intensity ($(a^{*2}+b^{*2})^{1/2}$) of the cakes' crumb and crust were calculated. Colour determinations were made 5x5 times in each cake: crumb or crust cake colour was checked at five different points on each cake and every point was measured five times. The five points were positioned in the centre of the cake and in the centre of four imaginary sectors in which it was divided along the diameter.

Crumb texture was determined by a TA-XT2 texture analyzer (Stable Microsystems, Surrey, UK) provided with the software *"Texture Expert"*. An Aluminium 25 mm diameter cylindrical probe was used in a *"Texture Profile Analysis"* double compression test (TPA) to penetrate to 50% depth, at 2 mm/s speed test, with a 30 s delay between first and second compression. Firmness (N), chewiness (N), cohesiveness, springiness and resilience were calculated from the TPA graphic (Gómez, Ronda, Caballero, Blanco & Rosell, 2007). In cake texture determinations, the crust was removed, and samples of 40x40x20 were used. Averaged results of eight determinations are presented.

2.6 Statistical analysis

In order to assess significant differences among samples, it was performed a multiple comparison analysis of samples using the program Statistica (99 Edition, 5.5 Version, StatSoft Inc.). Fisher's least significant differences (LSD) test was used to describe means with 95% confidence.

3. Results and discussion

3.1 Proximate composition of flours

The chemical composition of the diverse flours is detailed in Table 2. The chickpea flours had significantly ($p<0.05$) higher content of protein, fat, ash and fibre than the wheat flour. Protein content of chickpea flours ranged from 22.48 to 25.18g /100g, and crude fat values showed a wide variation, being comprised between 3.81 to 7.22 g/100g. No significant differences were found between the chickpea flours, and regarding the variety, Pedrosillano was the most different variety because of its higher moisture and protein content and its lower fat content.

3.2 Thermal behaviour of the wheat flour and the different chickpea flours

Viscometric parameters of the different chickpea flours were determined by using the RVA (Table 3). When a chickpea flour-water dispersion was heated, an increase in the apparent viscosity was observed due to the gelatinization of the starch, although the peak viscosity induced by these type of flours (877-1032 cP) was lower than the one promoted by the wheat flour (2621 cP). Chickpea flours resulted in pastes with lower peak viscosity, holding strength, breakdown, final viscosity and total setback than the wheat flour; this is likely due to their lower carbohydrate content (Table 2), and also their different protein content could affect the viscometric parameters (Morris, King & Rubenthaler, 1997). Very low breakdown was observed in the chickpea flours, ranging from 38 cP to 68 cP, in comparison with 893 cP obtained with the wheat flour. The breakdown is related to the ability of the starches to withstand heating at high temperature and shear stress, usually high values of breakdown are associated to high peak viscosities in cereals such as wheat, barley, millet, rye and sorghum (Ragaee & Abdel-Aal, 2006), although different behaviour has been observed in triticale (León, Barrera, Pérez, Ribotta & Rosell, 2005). When temperature decreased, an increase in viscosity was observed but chickpea flour induced lower viscosity during cooling than wheat flour. The increase in viscosity is related to the ability of the amylose chains to reassociate and form a gel and it is referred to as setback. Taking into account the low setback values obtained with chickpea flours, it could be expected that the replacement of wheat flour by chickpea flours would result in softer crumbs. No tendency was observed concerning the type of chickpea flour (whole or white), or chickpea cultivar.

3.3 Effect of chickpea flours on cake shape and size

In Table 4 the effect of composite flours containing chickpea flours on batter density and on cake volume and shape can be observed. The replacement of wheat flour for increasing amounts of chickpea flours decreased batter density when recipe A was used. Conversely, in recipe B, the presence of chickpea flour decreased air incorporation in the batter, yielding lower density. In both recipes, the whole composite flours resulted in high density batters, decreasing the air incorporation. Regarding chickpea cultivars, Pedrosillano gave the greatest batter density in recipe A, whereas Lechoso and Sinaloa brought about the highest batter density in recipe B.

It could have been expected that lower batter density would result in higher cake volume, as was the case with sponge cakes, but, in fact, the opposite phenomenon was observed in layer cakes. Handleman, Conn & Lyons (1961) found a relationship between batter density, viscosity and surface tension and the resulting cake characteristics, although some other parameters like the amount of gas, from the whipping process or from chemical leavening, entrapped into the batter, and the gas kept during baking affected cake quality.

Cake volume diminished as the chickpea flour percentage increased in both (A and B) cakes, especially in cake A. Cake B does not incorporate baking powder in its formulation, whilst cake A does. During the baking process, baking powder generates gases, which should be retained in order to guarantee good cake volume, and in that respect flour quality has an important role to play. Another important factor is the gelatinization temperature of the flour, as Miller & Trimbo (1965), Howard, Hughes, & Strobel (1968) and Howard (1972) pointed out for layer cakes, whereas Mizukoshi, Kawada & Matsui (1979) and Mizukoshi, Maeda & Amano (1980) reached the same conclusion for sponge cakes. The starch gelatinization at low temperatures would prevent the correct expansion of doughs.

As can be observed in Table 3, chickpea flours presented lower peak viscosity than wheat flours, thus lower gas retention and lower expansion of the product could be expected. Chickpea flours also presented higher protein content, and different amino acid composition than wheat flours which could affect cake characteristics, especially volume (Mohamed, Lajis & Hamid, 1995; Mohamed, S., & Hamid, N.A., 1998). As far as chickpea cultivars are concerned, Sinaloa and Lechoso gave cakes with higher volume, in both the A and B cakes, although in the latter no significant differences were found between Pedrosillano and Lechoso.

As for cake weight, no significant differences were found. Therefore, the water retention capacity was not affected by the substitution of wheat flour for chickpea flour, or by the kind of chickpea flour in sponge cakes. Amongst chickpea cultivars, small differences were also detected, but they could not be attributed to their different chemical composition.

The volume index is an indicator of cake volume and, as expected, followed a similar tendency to volume. Symmetry indicates the differences in height between the central zone and the lateral zone. Thus, a high symmetry suggests that cakes mainly rise in their central part, while a negative symmetry indicates that cake volume falls down at the end of the baking process. Hence, symmetry gives an idea about gas retention in the final baking phase. In both cases the incorporation of chickpea flour reduced their symmetry, and in the case of the A cakes with 100% of chickpea flour it became negative. This result supports the idea that cakes elaborated with chickpea flour had worse gas retention capacity during baking than those lacking legume flour, especially during the last baking phase.

The kind of chickpea flour exerted lower effect on symmetry, although the white flours had higher symmetry in sponge cakes, and thus, higher gas retention and higher final volume than layer cakes. In the case of layer cakes, small differences were observed, the whole flours produced cakes with the highest symmetry. The differences between the various chickpea cultivars were minimal in sponge cakes. In layer cakes, cultivars Lechoso and Sinaloa, the most similar in composition, generated cakes with the highest symmetry and final volume.

3.4 Effect of chickpea flours on cake colour

Crust colour in cakes varied with the quantity, the kind and the variety of chickpea flour (Table 5). This influence was more important in layer than in sponge cakes. The crust colour data of cakes are shown in table 5. Layer cakes became darker (lower L*) as the chickpea flour quantity increased. Pedrosillano also resulted in dark cakes. With regard to the kind of chickpea flour, whole flour produced brighter cakes. The hue angle indicates the tone; values near 0 indicate reddish tones whilst values near 90 indicate yellowish tones. Meanwhile, chroma values near 0 indicate subdued colours, whilst high chroma values indicate vivacious colours. The effect of the composite flours on the hue and chroma values was more evident in sponge cakes, where as the quantity of chickpea increased, the chroma and the hue were reduced. Chickpea cultivars had also an influence on these parameters, on both kinds of cakes, although this effect was more important in the A cakes. The crust colour of cakes, was generated in the baking process due to the Maillard reactions between sugars and amino acids, and the caramelization process of sugars. Therefore, the differences observed when the quantity of chickpea flour increased could be attributed to the high protein content and the different amino acid composition of the composite flours compared to the wheat flour. Differences between layer and sponge cakes seemed to result from their different formulations.

Cake crumb does not reach temperatures above 100ºC, so the Maillard or caramelization reactions by sugars fail to take place. Therefore, crumb colour must be the result of the raw materials colours and their interactions. The crumb colour data of cakes are shown in table 5. Cake A crumb was lightly darker than cake B crumb, and the chickpea flour addition reduced its luminosity, but this effect was only significant in the B cakes. Differences between chickpea cultivars were hardly observed. The greatest differences in crumb colour were observed in chroma, which increased as the amount of chickpea flour increased, and were more noticeable in the A cakes. In both cases, cakes elaborated with Pedrosillano flour presented the highest chroma, mainly due to the highest b* value. This effect was expected because of the more intense orange colour of Pedrosillano flours. Whole flours had the highest a* value and the lowest hue value in both kinds of cakes, but the effect of the kind of flour on b* and chroma values was minimum and different depending on the type of cake. These results agree with those obtained by Dodok et al. (1993), who observed that chickpea flour triggered the change in the crumb colour when they studied the addition of chickpea flour to bread doughs.

3.5 Influence of chickpea flours on cake texture

In table 6 the textural characteristics data can be observed. The influence of flours on the initial firmness was inversely proportional to cake volume. Therefore, the initial firmness increased when the percentage of chickpea flour increased, although this trend was not significant in layer cakes when 50% of chickpea flour was used to replace wheat flour. These results agree with those obtained by Guinot & Mathlouthi (1991), who observed that small additions of soy protein increased the firmness of sponge cakes. The cakes elaborated with whole flour were firmer than those elaborated with white flour, being this difference more important in sponge cakes. The differences between chickpea cultivars were only significant in layer cakes, where the cakes elaborated with Lechoso and Sinaloa were less firm than those elaborated with Pedrosillano.

The volume and the firmness of the A cakes presented a negative correlation, with an r^2 of 29.53. However, the r^2 increased up to 85.41 when samples containing 100% whole flour from cultivars Lechoso and Sinaloa were removed from this correlation. Whole cakes from these cultivars presented similar firmness than those obtained with cultivars Andaluz and Pedrosillano, but with higher cake volume. Cultivars Lechoso and Sinaloa had lower protein and water content but it could not be concluded that the chemical composition was responsible for the higher volume with a similar firmness. In the case of the B cakes, a negative correlation was observed between volume and firmness, with an r^2 of 45.16.

Among the other textural parameters, layer cakes were the most influenced by the composite flours. Cohesiveness decreased when the percentage of chickpea flour increased, but it was not affected by the kind and cultivar of chickpea. Gumminess and chewiness were lower in white flour cakes and with cultivars

Lechoso and Sinaloa. Adhesiveness was higher in cakes containing 100% chickpea flour and from cultivar Andaluz, although it did not present significant differences with Pedrosillano. Both springiness and resilience diminished when the chickpea flour percentage increased, whilst Lechoso and Sinaloa varieties presented the highest resilience values. In general, a similar behaviour between Lechoso and Sinaloa varieties versus Andaluz and Pedrosillano was observed, which resulted in cakes with higher firmness, gumminess and adhesiveness, but lower resilience.

In sponge cakes, as the percentage of chickpea flour increased, cohesiveness and resilience decreased, while gumminess, chewiness and adhesiveness increased. White flours produce less cohesive, more gummy and chewy, and with less resilience cakes. The chickpea variety had only a significant effect on cohesiveness, being cultivars Andaluz and Pedrosillano the ones that produced the most cohesive cakes.

Firmness trends over the storage time can be seen in figure 1, A (recipe A), and B (recipe B). The influence of chickpea cultivar on the firmness trend was not significant in any case. In cake A samples, no great differences in firmness increase pertaining to the composite flours were appreciated, although cakes elaborated with white chickpea flour stale more slowly than those elaborated with whole flour or with wheat flour. In cakes elaborated with 50% of both flours a gradual increase in firmness was observed, whilst in those elaborated with 100% of wheat or chickpea flour a higher firmness increase during the first week was observed, firming slightly slower in the second one. The effect of the composite flours was much evident in the B cakes, where as the percentage of chickpea flour increased, in both white and whole flour, the cakes hardened more quickly. After 14 days of storage, the B cakes elaborated with whole chickpea flour presented similar firmness to those elaborated with white flour, however their initial firmness was higher and thus the total firmness increase was lower. Unlike bread staling phenomena, hardening phenomena in cakes have been scarcely studied but it is known that these products develop complex systems, where several ingredients interact with each other and affect texture (Gelinas, Roy & Guillet, 1999). In general, hardening phenomena in cakes are attributed to crumb dehydration (Willhoft, 1973), which was avoided in this study by packaging the cakes, and to starch retrogradation (Gujral, Rosell, Sharma & Singh 2003).

In conclusion, the addition of 50% of chickpea flour would improve the nutritional value of cakes without greatly affecting their quality characteristics. Lechoso and Sinaloa would be the most adequate cultivars for enrichment, and white better than whole flour. Sponge cake quality was less affected by the chickpea addition than layer cakes, probably because of the lower flour percentage in its formula.

4. Acknowledgements

This work was financially supported by the Spanish Ministerio de Educación y Ciencia Project (MCYT, AGL2005-05192-C04). Authors would like to thank Alicia González for her collaboration in this study and Alfonso Centeno for his help in the translation to English.

5. References

AACC (2000). *Approved Methods of the American Association of Cereal Chemists, Method 10-91.* 10th edition. St. Paul (Minnesota): American Association of Cereal Chemists, Inc.

Anderson, J.W., & Major, A.W. (2002). Pulses and lipaemia, short- and long-term effect: Potential in the prevention of cardiovascular disease. *British Journal of Nutrition*, 88, suppl. 3, S263-271.

Bornet, F.R., Billaux, M.S., & Messing, B. (1997). Glycaemic index concept and metabolic diseases. *International Journal of Biology Macromolecules*, 21, 207-219.

Campos, J.E., & El-Dash, A.A. (1978). Effect of addition of full fat sweet lupine flour on rheological properties of dough and baking quality of bread. *Cereal Chemistry*, 55, 619-627.

Dervas, G., Doxastakisk, G., Hadjisavva-Zinoviadi, S., & Triantafillakos, N. (1999). Lupin flour addition to wheat flour doughs and effect on rheological properties. Food Chemsitry, 66(1), 67-73.

Dodok, L., Ali, M.A., Hozová, B., Halasová, G., & Polacek, I. (1993). Importance and utilization of chickpea in cereal technology. *Acta Alimentari*a, 22, 119-129.

Doxastakis, G., Zafiriadis, I., Irakli, M., & Tananaki, C. (2002). Lupin, soya and triticale addition to wheat flour doughs and their effect on rheological properties. Food Chemistry, 77(2), 219-227.

Eggum, B.O., & Beame, R.M. (1983). The nutritive value of seed proteins. In W. Gottschalk & P.H. Muller eds., *Seed Protein Biochemistry, Genetics and Nutritive Value*, (pp. 499-531). The Hague:Junk.

Fernandez, M.L., & Berry, J.W. (1989). Rheological properties of flour and sensory characteristics of bread made from germinated chickpea. *International Journal of Food Science and Technology*, 24, 103-110.

Finney, P.L., Morad, M.M., & Hubbard, J.D. (1980). Germinated and ungerminated faba bean in conventional U.S. breads made with and without sugar and in Egyptian balady breads. *Cereal Chemistry*, 57, 267-270.

Gelinas, P., Roy, G., & Guillet, M. (1999). Relative effects of ingredients on cake staling based on an accelerated shelf-life test. *Journal of Food Science*, 64, 937-940.

Gómez, M., Ronda, F., Caballero, P., Blanco, C., & Rosell, C.M. (2006). Functionality of different hydrocolloids on the quality and shelf-life of yellow layer cakes. Food Hydrocolloids, 21:167-173.

Guinot, P., & Mathlouthi, M. (1991). Instron measurement of sponge cake firmness: Effect of additives and storage conditions. *Journal of the Science of Food and Agriculture*, 54, 413-420.

Gujral, H.S., Rosell, C.M., Sharma, S., & Singh, S. (2003). Effect of sodium lauryl sulphate on the texture of sponge cake. Food Science and Technology International, 9, 89-93.

Handleman, A.R., Conn, J.F., & Lyons, J.W. (1961). Bubble mechanics in thick foams and their effects on cake quality. *Cereal Chemistry*, 38, 294-305.

Howard, N.B. (1972). The role of some essential ingredients in the formation of layer cake structures. *Bakers Digest*, 46 (5), 28-37.

Howard, N.B., Hughes, D.H., & Strobel, R.G.K. (1968). Function of the starch granule in the formation of layer cake structure. *Cereal Chemistry*, 45, 329-338.

Iyer, L., & Singh, U. (1997). Functional properties of wheat and chickpea composite flours. *Food Australia*, 49, 27-31.

León, A.E., Barrera, G.N., Pérez, G.T., Ribotta, P.D., Rosell, C.M. (2005). Effect of damaged starch levels on flour thermal behaviour and bread staling. *European Food Research and Technology*. doi:10.1007/s00217-006-0297-x.

Leterme, P. (2002). Recommendations by health organizations for pulse consumption. *British Journal of Nutrition*, 88, suppl. 3, S239-242.

Livingstone, A.S., Feng, J.J., & Malleshi, N.G. (1993). Development and nutritional quality evaluation of weaning foods based on malted, popped and dried wheat and chickpea. *International Journal of Food Science and Technology*, 28, 35-43.

Lorimer, N.L., Zabik, M.E., Harte, J.B., Stachiw, N.C., & Uebersax, M.A. (1991). Effect of navy bean protein flour and navy bean globulin(s) on composite flour rheology, chemical bonding, and microstructure. *Cereal Chemistry*, 68, 213-220.

Lucisano, M., & Pompei, C. (1981). Baking properties of lupin flour. *Lebensmittel-Wissenchaft & Technologie*, 14, 323-330.

Mathers, J.C. (2002). Pulses and cancinogenesis: potential for the prevention of colon, breast and other cancers. *British Journal of Nutrition*, 88, suppl. 3, S273-279.

Miller, B.S., & Trimbo, H.B. (1965). Gelatinization of starch and white layer cake quality. *Food Technology*, 19, 208-216.

Mizukoshi, M., Kawada, T., & Matsui, N. (1979). Model studies of cake baking. I. Continuous observations of starch gelatinization and protein coagulation during baking. *Cereal Chemistry*, 56, 305-309.

Mizukoshi, M., Maeda, H., & Amano, H. (1980). Model studies of cake baking, II. Expansion and heat set of cake batter during baking. *Cereal Chemistry*, 55, 352-355.

Mohamed, S., & Hamid, N.A. (1998). Effects of ingredients on the characteristics of rice cakes. *Journal of the Science of Food and Agricultur*e, 76(3), 464-468.

Mohamed, S., Lajis, S.M.M., & Hamid, N.A. (1995). Effects of protein from different sources on the characteristics of sponge cakes, rice cakes (apam), doughnuts and frying batters. *Journal of the Science of Food and Agriculture*, 68, 271-277.

Morad, M.M., Leung, H.K., Hsu, D.L., & Finney, P.L. (1980). Effect of germination on physicochemical and bread-baking properties of yellow pea, lentil, and faba bean flours and starches. *Cereal Chemistry*, 57, 390-396.

Morris, C., King, G.E., Rubenthaler, G.L. (1997). Contribution of wheat flour fractions to peak hot paste viscosity. *Cereal Chemistry*, 74, 147-153.

Morrow, B. (1991). The rebirth of legumes. *Food Technology*, 45(9), 96-121.

Pollard, N.J., Stoddard, F.L., Popineau, Y., Wrigley, C.W., & MacRitchie, F. (2002). Lupin flours as additives: Dough mixing, breadmaking, emulsifying, and foaming. *Cereal Chemistry*, 79, 662-669.

Ragaee, S., & Abdel-Aal, E.M. (2006). Pasting properties of starch and protein in selected cereals and quality of their food products. *Food Chemistry*, 95, 9-18.

Rizkalla, S.W., Bellisle, F., & Slama, G. (2002). Health benefits of low glycaemic index foods, such as pulses, in diabetic patients and healthy individuals. *British Journal of Nutrition*, 88, suppl. 3, S255-262.

Sadowska, J., Blaszczak, W., Fornal, J., Vidal-Valverde, C., & Frias, J. (2003). Changes of wheat dough and bread quality and structure as a result of germinated pea flour addition. *European Food Research and Technology*, 216, 46-50.

Sadowska, J., Fornal, J., Vidal-Valverde, C., & Frias, J. (1999). Natural fermentation of lentils. Functional properties and potential in breadmaking of fermented lentil flour. *Nahrung*, 43, 396-401.

Schneider, A.V.C. (2002). Overview of the market and consumption of pulses in Europe. *British Journal of Nutrition*, 88, suppl. 3, S243-250.

Shehata, N.A., Darwish, N., El-Nahry, F., & Andel-Razek, F.A. (1988). Supplementation of wheat flour with some local legumes. *Nahrung*, 32, 3-8.

Singh, N., Harinder, K., Sekhon, K.S., & Kaur, B. (1991). Studies on the improvement of functional and baking properties of wheat-chickpea flour blends. *Journal of Food Processing and Preservation*, 15, 391-402.

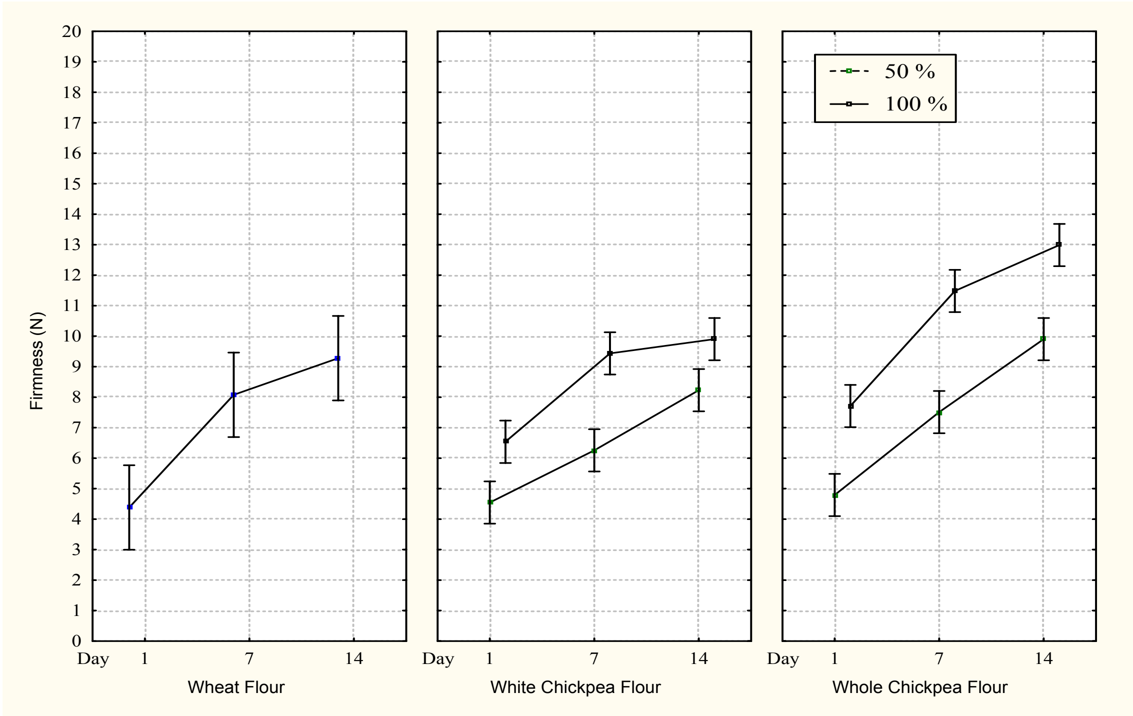
Tharanathan, R.N., & Mahadevamma, S. (2003). Grain legumes – a boon to human nutrition. *Trends in Food Science and Technology*, 14, 507-518.

Willhoft, E.M.A. (1973). Mechanism and theory of staling of bread and baked goods, and associated changes in textural properties. *Journal of Texture Studie*s, 4, 292-322.

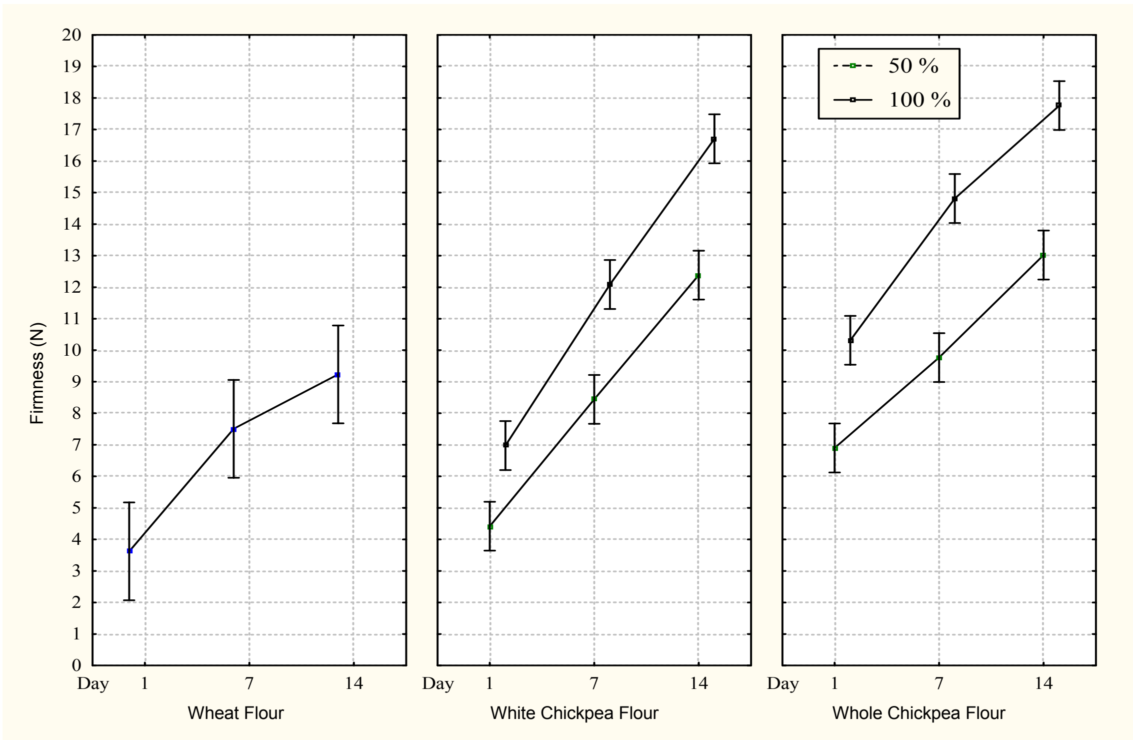
FIGURE CAPTIONS

Figure 1: Effect of the composite flours on the firmness of cakes during storage. A: Cakes obtained from recipe A. B: Cakes obtained from recipe B.

Figure 1. A.


Firmness (N)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Day 1 7 14
Wheat Flour
White Chickpea Flour
Whole Chickpea Flour
50 %
100 %

B.


Firmness (N)
0
1
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16
17
18
19
20
Day 1 7 14
Wheat Flour
White Chickpea Flour
Whole Chickpea Flour
50 %
100 %

Table 1: Cake formulations

Ingredients	A Cake		B Cake	
	(g)	%	(g)	%
Flour	700	27.5	490	26.5
Egg	350	13.8	688	37.3
Sugar	840	33	481	26
Powder Milk	42	1.6	50	2.7
Water	378	14.9	110	6
Oil	210	8.4	-	-
Emulsifier	-	-	28	1.5
Baking powder	21	0.8	-	-

Table 2: Proximate composition (g/100g) of wheat and chickpea flours

Kind of flour	Chickpea Cultivar	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrates (by difference)
Wheat		10.81d	13.73a	1.40a	0.16a	0.78a	73.12c
Chickpea White	Andaluz	7.94b	24.65e	7.22f	1.36c	3.27b	55.56a
	Lechoso	8.02b	23.46cd	6.26d	1.14b	3.31b	57.81b
	Pedrosillano	8.47c	25.18f	4.62c	1.37c	3.46d	56.90ab
	Sinaloa	8.02b	23.09c	6.34de	1.41c	3.27b	57.87b
Chickpea Whole	Andaluz	7.98b	23.63d	6.87ef	2.72e	3.30b	55.50a
	Lechoso	7.44a	23.06c	6.76e	2.75ef	3.38c	56.61ab
	Pedrosillano	8.21bc	24.93ef	3.81b	2.78f	3.46d	56.81ab
	Sinaloa	7.26a	22.48b	6.58e	2.64d	3.44d	57.60b

Different letters in the same column are significantly different ($P<0.05$)

Table 3. Viscometric parameters of different flours during cooking and cooling determined by the Rapid Visco Analyser.

Kind of flour	Chickpea cultivar	Viscometric parameters on cooking and cooling (Rapid Visco Analyser)						
		Peak viscosity	Peak Time	Pasting Temperature	Holding strength	Breakdown	Total Setback	Final Viscosity
		cP	min	ºC	cP	cP	cP	cP
Wheat		2621 e	6.3 b	50.1 a	1728 e	893 c	1485 c	3213 e
White chickpea	Andaluz	954 b	5.9 a	79.1 d	888 b	66 b	258 a	1146 b
	Lechoso	877 a	6.1 a	76.7 c	817 a	60 b	249 a	1066 a
	Pedrosillano	1001 c	6.4 b	79.8 d	963 d	38 a	247 a	1210 c
	Sinaloa	978 c	5.9 a	72.6 b	930 c	48 a	281 b	1211 c
Whole chickpea	Andaluz	936 b	6.9 c	79.1 d	887 b	49 a	279 b	1166 b
	Lechoso	1032 d	5.9 a	76.0 c	964 d	68 b	300 b	1264 d
	Pedrosillano	976 c	6.7 c	76.0 c	935 c	41 a	285 b	1220 c
	Sinaloa	987 c	6.7 c	75.9 c	919 c	68 b	275 b	1194 c

Different letters in the same column are significantly different ($P<0.05$)

Table 4: Physical characteristics of batters and cakes

	Batter density		Volume (cm^3)		Weight (g)		Simetry		Volume Index	
	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake
Wheat flour / Chickpea flour										
100 / 0	1.05c	0.51a	397.50c	465.00c	183.50a	131.00a	39.90c	26.89c	171.10c	150.94b
50 /50	0.98b	0.58b	373.90b	455.31b	183.63a	130.81a	9.63b	20.72b	147.02b	145.71b
0/100	0.94a	0.60c	348.75a	434.69a	186.00b	131.06a	-3.76a	9.84a	125.22a	133.19a
Kind of flour										
White	0.95a	0.58a	360.16a	469.06b	185.50b	131.25a	0.82a	21.32b	137.77a	149.94b
Whole	0.96b	0.60b	362.50a	420.94a	184.13a	130.63a	5.05b	9.24a	134.47a	128.96a
Chickpea cultivar										
Andaluz	0.96b	0.62c	324.38a	418.75a	185.13cd	130.75a	-3.34a	14.30ab	127.40a	138.16a
Lechoso	0.96b	0.57a	398.13b	453.13bc	183.63a	130.88a	5.09b	16.57b	141.97b	137.54a
Pedrosillano	0.94a	0.60b	324.38a	448.13b	184.63bc	130.88a	-0.17a	17.01b	130.91a	142.94b
Sinaloa	0.98c	0.57a	388.75b	460.00c	185.88d	131.25a	10.15c	13.24a	144.19b	139.16a

Different letters in the same column are significantly different ($P<0.05$)

Table 5: Crust and crumb colour of cakes

	Crust										Crumb									
	L*		a*		b*		Chroma		Hue angle		L*		a*		b*		Chroma		Hue angle	
	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake
Wheat flour / Chickpea flour																				
100 / 0	50.13c	44.03a	11.73a	14.16b	12.53ab	23.74b	17.23ab	27.64b	46.11a	59.17b	66.79a	74.51b	1.41b	0.22a	15.81a	22.92a	15.87a	22.92a	84.89a	89.46b
50 / 50	44.77b	46.17b	11.52a	13.36ab	14.84b	15.80a	18.91b	20.86a	51.46b	48.67a	64.80a	74.47b	0.69a	0.40a	21.60b	22.48a	21.62b	22.49a	88.16c	88.94b
0 / 100	38.82a	45.05a	11.36a	13.18a	11.31a	15.08a	16.26a	20.10a	43.60a	48.36a	63.56a	72.80a	1.28b	1.15b	27.16c	26.68	27.20c	26.72b	87.23b	87.48a
Kind of flour																				
White	40.46a	44.15a	10.95a	12.86a	12.53a	16.49a	17.01a	21.00a	46.91a	51.50b	62.77a	73.79a	0.81a	0.52a	23.79a	25.64b	23.83a	25.65b	88.06b	88.89b
Whole	43.14b	47.08b	11.94b	13.67b	12.53a	14.39a	18.17a	19.97a	48.14a	45.53a	65.59b	73.48a	1.16b	1.03b	24.97b	23.52a	25.00b	23.55a	87.33a	87.53a
Chickpea Cultivar																				
Andaluz	43.87b	44.46a	11.90b	13.24ab	10.06a	14.31ab	15.71a	19.52a	39.48a	47.14ab	65.87b	73.67ab	1.64c	0.87a	23.29a	24.20a	23.36a	24.22a	85.93a	87.99a
Lechoso	42.53b	44.72a	11.62b	13.00a	17.02c	16.38ab	20.65c	21.14a	55.41b	50.18ab	63.20ab	72.88a	0.40a	0.68a	23.58a	23.41a	23.59a	23.44a	88.97c	88.33a
Pedrosillano	36.60a	46.35b	10.23a	13.64b	11.81ab	17.11b	15.69a	21.93a	48.54b	51.02b	61.95a	74.05b	1.29b	0.77a	27.57b	26.93b	27.60b	26.95b	87.35b	88.46a
Sinaloa	44.19b	46.92b	12.03b	13.19ab	13.40b	13.95a	18.30b	19.33a	46.67b	45.73a	65.72b	73.95b	0.61a	0.78a	23.08a	23.78a	23.10a	23.81a	88.54c	88.06a

Different letters in the same column are significantly different ($P<0.05$)

Table 6: Texture of fresh cakes

	Firmness (N)		Cohesiveness		Gumminess (N)		Chewiness (N)		Adhesiveness (N·s)		Springiness		Resilience	
	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake	A Cake	B Cake
Wheat flour / Chickpea flour														
100 / 0	4.38a	3.62a	0.68c	0.76c	2.98ab	2.74a	2.62b	2.45a	0.05b	0.09a	0.88c	0.89a	0.23c	0.27b
50 /50	4.67a	5.66b	0.56b	0.72b	2.59a	4.02b	2.06a	3.67a	0.11b	0.10a	0.80b	0.91a	0.17b	0.26b
0/100	7.12b	8.65c	0.47a	0.61a	3.35b	5.16c	2.36b	4.53b	0.41a	0.12a	0.71a	0.88a	0.13a	0.21a
Kind of flour														
White	5.54a	5.70a	0.51a	0.69b	2.76a	3.87a	2.07a	3.47a	0.25a	0.08a	0.75a	0.90a	0.15a	0.25b
Whole	6.25b	8.61b	0.52a	0.63a	3.18b	5.31b	2.36b	4.73b	0.27a	0.08a	0.75a	0.89a	0.16a	0.22a
Chickpea Cultivar														
Andaluz	6.15ab	7.15a	0.52a	0.67b	3.16b	4.61a	2.36bc	4.11a	0.43a	0.09a	0.75a	0.90a	0.15a	0.24a
Lechoso	5.22a	7.74a	0.52a	0.65a	2.62a	4.81a	1.96a	4.30a	0.17b	0.08a	0.75a	0.90a	0.16b	0.23a
Pedrosillano	6.97b	6.98a	0.51a	0.67b	3.44b	4.61a	2.53c	4.11a	0.27ab	0.07a	0.75a	0.89a	0.15a	0.24a
Sinaloa	5.24a	6.73a	0.52a	0.66ab	2.66a	4.33a	2.00ab	3.88a	0.18b	0.05a	0.75a	0.90a	0.16b	0.24a

Different letters in the same column are significantly different ($P<0.05$)