EUROPEAN ACADEMIC RESEARCH
Vol. IV, Issue 11/ February 2017

ISSN 2286-4822
www.euacademic.org

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

Dietary Fibers Effect from Mango Peels and Date Seeds on Rheological properties of Arabic Bread Quality: A Novel approach on applying Fuzzy Modeling in Studying Rolling/Folding and Tearing values

ABU-GHOUSH, MAHMOUD
Department of Clinical Nutrition and Dietetics
The Hashemite University, Zarqa, Jordan
AL-DALALI, SAM SALEH[1]
Department of Food Science and Technology
Ibb University, Ibb, Yemen
Department of Food and Nutrition Sciences
King Faisal University, Saudi Arabia
ALEID, SALAH MOHAMMED
Department of Food and Nutrition Sciences
King Faisal University, Saudi Arabia
SAMHOURI, MURAD
Department of Clinical Nutrition and Dietetics
The Hashemite University, Zarqa, Jordan

Abstract:

The aim of this study is to evaluate effects of dietary fibers of Mango peels (MP) and Date seeds (DS) on the quality of Arabic bread (AB). DS was added at 4% and 6%, and MP at two levels (2% and 4%). Results showed that adding MP and DS increased water absorption and stability of dough. DS increased mixing tolerance index (MTI), whereas MP decreased MTI compared to control. An adaptive neuro-fuzzy inference system (ANFIS) is used study the properties of the wheat flour with the proportions of (M) and (D), elapsed time of one day (Day 1) and two days (Day 2), as inputs, and two output properties

[1] **Corresponding author:** salihsam4@gmail.com

(rolling/folding and tearing values (Tear)). Experimental validation runs were conducted to compare the measured values and the predicted ones. The comparison shows that the adoption of this neuro- modeling technique (i.e., ANFIS) achieved a satisfactory prediction accuracy of about 92%.

Key words: Arabic bread, Dietary Fiber, Rheological properties, Fuzzy modeling

INTRODUCTION

Flat Arabic bread has two layers, a round shape, crust color which is golden brown and it forms pocket during baking. Arabic bread is made from simple ingredients including flour, salt, yeast and water (Qarooni 1990, Mir et al., 2014; AL-Dmoor 2012, Abu Ghoush et al., 2008a; Abu Ghoush et al., 2008b).

The demand for arabic bread that is rich in dietary fiber (DF), is increasing (Ajila et al., 2008; Criqui & Ringel, 1994). It was found that date seeds might be used at 10% replacement level in wheat flour to produce Saudi Mafrood flat bread without any significant adverse effects on quality (Almana & Mahmoud,1994). Wang et al., (2002) used carob fiber, inulin and pea fiber in breadmaking.

Mango fruits production reached more than 35 million tons (FAO, 2009). It was reported that mango DF concentrate contained low lipid, high starch content and balanced soluble dietary fiber/insoluble dietary fiber levels (Ashoush & Gadallah, 2011; Loelillet, 1994; Beerh et al., 1976; Vergara Valencia et al., 2007). The dietary fiber from *Mangifera pajang Kort* can be used as a suitable source to enhance nutritional value for bakery products (AL-Sheraji et al., 2011).

Date seeds are used in human or animal feed (Almana & Mahmoud, 1994). The seeds represent about 10 – 12% from the fruit (Platat et al., 2014; Platat et al., 2015). The date seed increased the dietary fiber content when added to bread with slight adverse effects on bread quality (Bouaziz et al., 2010).

Fuzzy logic and fuzzy inference system (FIS) is an effective technique for the identification and modeling of complex nonlinear systems. Fuzzy logic is particularly attractive due to its ability to solve problems in the absence of accurate mathematical models. The prediction of properties of the wheat flour (i.e., rolling/folding and tearing) is considered complex system, so using the conventional technology to model these properties results in significant discrepancies between simulation results and experimental data. Thus, this complex nonlinear system fits within the realm of neuro-fuzzy techniques. The application of a neuro-fuzzy inference system to prediction and modeling is a novel approach that overcomes limitations of a fuzzy inference system such as the dependency on the expert for fuzzy rule generation and design of the non-adaptive fuzzy set.

Modeling and identification of food properties and processing has been the subject of many researchers in the food engineering field. Perrot et al., (2003) presented a hybrid approach based on fuzzy logic and genetic algorithms to control a crossflow microfiltration pilot plant. The results of simulations and pilot tests showed that it becomes possible to impose dynamics to the process that leads to maintain the state variable at a given reference. Tsourveloudis & Kiralakis, (2002) applied a rotary drying process to olive stones. They described and modeled the process using fuzzy and neuro-fuzzy techniques based on available expertise and knowledge for a given, industrial size, rotary dryer. They also used ANFIS controller based on data taken from an empirical model of the dryer under study.

Apple grading using fuzzy logic was introduced by (Kavdir & Guyer, 2003). Fuzzy logic was applied as a decision making support to grade apples. Grading results obtained from fuzzy logic showed 89% general agreement with results obtained from human expert, providing good flexibility in reflecting the expert's expectations and grading standards into the results.

The present study aims at evaluating the effect of dietary fiber of MP and DS on the rheological properties of the dough and applying neuro fuzzy modeling for prediction of rolling/folding and tearing properties of the bread.

MATERIAL AND METHODS

Material

Hard wheat flour from Yecora Rojo variety (Extraction rate 75%) was obtained from the local market in Al-Ahsa, produced by Grain Silos and Flour Mills Organization; Dammam Saudi Arabia in 2014. Commercial safe-instant dry compressed yeast (Manufactured in France by S.I.Lesaffre59703 Marcq France) and commercial iodized table salt (locally purchased) were used in this study. From preliminary trials, MP (2% and 4%), DS (4% and 6%) and their mix (1:1) have better bread quality.

Preparation of fiber sources

MP was prepared according to (Ajila et al., 2008), whereas DS was prepared according to (Almana & Mahmoud, 1994). However, a 200 mm sieve was used in this study.

Dough Rheological properties

The effect of fiber sources on dough rheological was determined by using Farinograph (Brabender, GmbH and Co. KG–Model No. 827504, Germany) according to (AACC, 1995) standard method 54–21. Measured parameters included water absorption, Dough development time (DDT), Dough stability and Mixing tolerance index (MIX).

Arabic bread baking

Arabic bread was made according to Qarooni et al., (1987). In brief, flour 700g, salt 10.5g and instant active dry yeast 3.5g were mixed for 1 min using lab mixer (Tekno stamp, Italy). Water was added with mixing for 2 min at low speed. Then, 2 min at medium speed. Finally, 4 min at high speed. After one hour of bulk fermentation at 30˚C and 90 – 95% relative humidity, the dough was divided into 80g pieces, manually rounded and left for 15 min. following the same previous conditions. Dough pieces were sheeted (2mm thickness). All sheeted doughs were kept in proofing cabinet for 30 min. at the same condition. The proofed dough pieces were kept on a hot solid aluminum tray, and baked at 450-500˚C for 45–55 seconds. The baked loaves were cooled for 15min., wrapped in plastic sacks and stored at room temperature.

Sensory Evaluation

Evaluation of Arabic bread quality was performed by sensory assessment according to (Qarooni et al., 1989) after 1 hour and 24 hours of baking.

Fuzzy Modeling of Output Properties

Neuro-fuzzy is an associative memory system that consists of fuzzy nodes instead of simple input and ouput nodes. Neuro-fuzzy uses neural network learning functions to refine each part of the fuzzy knowledge separately. Learning in a separated network is faster than learning in a whole network. One approach to the derivation of a fuzzy rule base is to use the self learning features of artificial neural networks, to define the membership function based on input-output data. A fuzzy inference system (consisting of rules, fuzzy set membership functions, and the defuzzification strategy) are mapped onto a neural network-like architecture.

Adaptive neuro-fuzzy inference system (ANFIS) is a fuzzy inference system implemented in the framework of an adaptive neural network. By using a hybrid learning procedure, ANFIS can construct an input-output mapping based on both human-knowledge as fuzzy. If-Then rules and stipulated input-output data pairs for neural networks training. ANFIS architecture is shown in Figure (1), where x and y are the inputs, f is the output, A_i and A^2_n are the input membership functions, w_i and w^2_n are the rules firing strengths. Five network layers are used by ANFIS to perform the following fuzzy inference steps: (i) input fuzzification, (ii) fuzzy set database construction, (iii) fuzzy rule base construction (iv) decision making, and (v) output defuzzification. This is a multi-layered neural network architecture where the first layer represents the antecedent fuzzy sets, while the consequent fuzzy sets are represented by the middle layers, and the defuzzification strategy by the output layer. The nodes which have 'square' shape are those containing adaptable parameters, whereas the 'circular' nodes are those with fixed parameters.

ANFIS is more powerful than the simple fuzzy logic algorithm and neural networks, since it provides a method for fuzzy modeling to learn information about the data set, in order to compute the membership function parameters that best allow the associated fuzzy inference system to track the given input/output data (Jang, 1993). ANFIS also employs sugeno-type fuzzy inference system, which is a natural and efficient modeling tool, and is suited for modeling non-linear system by interpolating between multiple linear models. In addition, ANFIS is more powerful than neural network system since it is better than all of them in convergence rates (running time), average training error, root mean square error, and the coefficient of correlation, and it has a built-in ability to validate the modeled system. On the other hand, ANFIS is much more complex than the fuzzy inference systems, and is not available for all of the fuzzy inference system options. It only has a single output, and no rule sharing. In addition, ANFIS cannot accept all the customization options that basic fuzzy inference allows. That is, no possibility to make our own membership functions and defuzzification functions; the ones provided by ANFIS must be used.

ANFIS Modeling of Rolling/Folding and Tearing Properties

An adaptive neuro-fuzzy inference system (ANFIS) is an architecture which is functionally equivalent to a Sugeno-type fuzzy rule base. ANFIS is a method for tuning an existing rule base with a learning algorithm based on a collection of training data. This allows the rule base to adapt. Training data is used to teach the neuro-fuzzy system by adapting its parameters (which in essence are fuzzy set membership function parameters) and using a standard neural network algorithm which utilizes a gradient search, such that the mean square output error is minimized.

The architecture of ANFIS, illustrated in Figure (1), has five layers to accomplish the tuning process of the fuzzy modeling system. The five layers are:

1) Layer 1: Every node in this layer is an adaptive node with a node function (i.e., membership function). Parameters of membership functions are referred to as premise or antecedent parameters.
2) Layer 2: Every node in this layer is a fixed node, which multiplies the incoming signals and sends the product out. Each node represents the firing strength of a fuzzy rule.
3) Layer 3: Every node in this layer is a fixed node which calculates the ratio of the one firing strength to the sum of all rules' firing strengths. The outputs of this layer are called normalized firing strengths.

4) Layer 4: Every node in this layer is an adaptive node with a node function (i.e., linear combination of input variables). Parameters in this layer are referred to as consequent parameters.
5) Layer 5: The single node in this layer is a fixed node that computes the overall output as the summation of all incoming signals, shown in Figure (1), it is observed that given the values of premise parameters, the overall output can be expressed as a linear combination of the consequent parameters.

ANFIS applies two techniques in updating parameters. For premise parameters that define membership functions, ANFIS employs gradient descent back-propagation neural networks to fine-tune them. For consequent parameters that define the coefficient of each output equation, ANFIS uses that least squares method to identify them. This approach is called the hybrid learning method. More specifically, in the forward pass of the hybrid learning method, functional signals go forward until layer 4 and the consequent parameters are identified by the least square estimate. In the backward pass, the error rates propagate backward and the premise parameters are updated by the gradient descent.

ANFIS modeling and prediction of the output properties (i.e., rolling/folding (RollFold), and tearing (Tear)) starts by obtaining a data set (input-output data points) and dividing it into training and validating data sets. Each input/output pair contains four inputs (i.e., Proportion of Mango peel (M), proportion of date seed (D), time elapsed (Day 1), and time elapsed (Day 2) and two outputs (i.e., rolling/folding property (RollFold) and tearing property (Tear)). The training data set is used to find the initial premise parameters for the membership functions by equally spacing each of the membership functions. A threshold value for error between the actual and desired output is determined. The consequent parameters are computed using the least squares method. Then, an error for each data pairs is found. If this error is larger than the threshold value, the premise parameters are updated using the back propagation neural networks. This process is terminated when the error becomes less than the threshold value. Then, the testing data points are used to compare the model with actual system for validating purposes.

Statistical Analysis

All data were expressed as mean values ± SD. Statistical analysis was performed using one way analysis of variance (ANOVA). Comparisons between means were tested by Duncan's multiple range test with $p \leq 0.05$ being considered statistically significant. Statistical analysis was conducted with SAS software (SAS, 2002).

RESULTS AND DISCUSSION

Dough rheological properties

The Farinograph water absorption for wheat flour used in this study was 57.8% (corrected to 14%). It was found that addition of DS at 6% level to flour increased significantly dough water absorption to 62.73% ($p \leq 0.05$) whereas MP and the mix (MP+DS) gave lower water absorption compared with DS as shown in Table (1). It was reported in several previous studies that the increase in the water absorption was due to bran addition to the flour from different sources (Pomeranz et al., 1977; Sudha et al., 2007; Ajila et al., 2008; Almana & Mahmoud 1994). The increase in water absorption is caused by the great number of hydroxyl groups being in the fiber structure, which allows more water interaction through hydrogen bonding (Rosell et al., 2001; Wang et al., 2002). Dough development time (DDT) and stability values are good indicators of the flour strength. These fibers did not affect the DDT with the exception of DS at level 4% and the mix which showed a decreasing effect. Dough stability increased ($p \leq 0.05$) with fiber sources, DS at level of 6% gave higher stability compared to other treatment (Table 5). These results are in agreement with Bouaziz, (2010) who found that the use of DS fiber concentrate significantly increased dough stability compared to control. This finding is in disagreement to the results reported by Laurikainen et al., (1998) who found an increase of the DDT and a decrease of the Dough stability caused by adding 5% rye bran. The mixing tolerance index (MTI) was significantly reduced ($p \leq 0.05$) with the addition of MP at 2 and 4% levels compared to control. On the other hand, MTI increased significantly ($p \leq 0.05$) when DS and the mix were added (Table 1). These results may be caused by the interaction between fibers and gluten (Wang et al., 2002), or due to the interactions between fiber, water and flour gluten (Bouaziz et al., 2010).

Ability of Rolling and Folding on First Day and Second Day

The ability of rolling and folding of Arabic bread was evaluated in the first and second days. There was no significant effect on rolling and folding for control, MP (2 and 4%), DS (4%) and the mix treatments on the first day, while the same treatments showed significant reduction ($p \leq 0.05$) on the second day with exception of MP at level 2% and control (Table 2). Arabic bread with DS at level 6% showed significant effect ($p \leq 0.05$) in first and second days on the rolling and folding characters.

Tearing on First Day and Second Day

The ability of Arabic bread for tearing was evaluated on first and second day. MP showed no significant effect in Arabic bread tearing on first and second days compared to control.

While DS (4 and 6%) and MIX showed significant effect ($p \leq 0.05$) in Arabic bread tearing on first and second day (Table 2).

ANFIS Modeling

The fuzzy logic toolbox of Matlab 7.0 was used to obtain the results, and to build a fuzzy model for the (RollFold) and (Tear). **Figures (2 and 3)** show the training curves for building fuzzy models for Roll, Fold and Tear. 82 data points were used for training the system to predict each property. 50 neural nets learning epochs were used in Roll, Fold system and 200 in Tear system to get a low error of training (i.e., RMSE = 1.21 or 9% for Roll, Fold, and 1.02 or 8% for Tear). The comparisons between the actual and ANFIS predicted Roll, Fold and Tear after training are shown in **Figures (4 and 5**, respectively), which show that the systems are well-trained to model the actual rolling/folding and tearing values.

Twenty data points, which are different and independent from the training data, were used to validate the systems. The final fuzzy inference systems that predict the RollFold and Tear are shown in **Figures (6 and 7**, respectively). As illustrated in **Figures (8 and 9),** a three (Gaussian) type membership functions for each rolling/folding inputs (4 inputs) and a two (Bell-shaped) type membership functions for each tearing inputs (4 inputs), resulted in high accurate prediction results for both RollFold and Tear. The final fuzzy-based prediction model for RollFold and Tear are illustrated in **Figures (10 and 11**, respectively).

Models Validation

The ANFIS prediction models for rolling/folding (RollFold) and tearing (Tear) were validated by selecting a certain number of data points (i.e., 20 points), different from the other 82 points used for ANFIS training. Each validation data point (i.e., Mango peel (M), dates seed (D), elapsed time (Day 1), and elapsed time (Day 2)) was fed into the system, and then the predicted properties (i.e., RollFold and Tear) were compared to the actual values of the measured RollFold and Tear values. The average percent errors in the modeling of RollFold and Tear were 9% and 8% for RollFold and Tear respectively, achieving an accuracy of RollFold prediction of 91%, and of Tear prediction of 92%. **Table (3**) shows the data points used in system's validation along with the actual and predicted RollFold and Tear values, and the percent errors in the predictions. This table shows that the ANFIS predicted values are a close match of the actual ones.

CONCLUSIONS

Addition of MP and DS increased water absorption and dough stability compared to control. An increase in MTI due to DS addition was observed. However, MP showed a decreasing effect on MTI compared to control. ANFIS models achieved an overall average prediction error of wheat flour rolling/folding and tearing of only 8%. The present study shows that ANFIS is a technique that can be used efficiently to predict the food properties. It is believed that this approach can be applied to predict many other parameters and properties in food industry.

REFERENCES

1. AACC. (1995). Approved methods of the AACC. St. Paul, MN.U.S.A.
2. Abu Ghoush, M., Herald, T., Dowell, F., Xie, F, Aramouni, F., and Madl, R. (2008a). Effect Of Preservatives Addition On The Shelf Life Extensions And Quality Of Flat Bread As Determined By Near Infrared Spectroscopy And Texture

Analysis. *International Journal of Food Science and Technology*, 43, 357-364.

3. Abu Ghoush, M., Herald, T., Dowell, F. and Xie, F. (2008b). Effect of antimicrobial agents and dough conditioners on the shelf-life extension and quality of flat bread, as determined by near-infrared spectroscopy. *International Journal of Food Science and Technology*, 43, 365-372.
4. Ajila, C. M., and Prasada Rao, U. J. S. (2013). Mango peel dietary fibre: Composition and associated bound phenolics. *J. of functional foods*, 5**,** 444 –450.
5. Ajila, C. M., Leelavathi, K. A., and Prasada Rao, U. J. S. (2008). Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporating of mango peel powder. *Journal of cereal science*, 48**,** 319-326.
6. Al-Dmoor, H. M. (2012). Flat bread: ingredients and fortification. Quality Assurance and Safety of Crops & Foods, 4, 2–8.
7. Aleid, S. M., Al-Hulaibi, A. A., Abu-Ghoush, M. A., and Al-Shathri, A. A. (2014). Enhancing arabic bread quality and shelf life stability using bread improvers. *J Food Sci Technol*, 52(8), 4761-4772.
8. Almana, H. A. A., and Mahmoud, R. M. (1994). Palm date seeds As an alternative source of dietary fiber in Saudi bread. *Ecology of food and Nutrition*, 32**,** 261-270.
9. Al-Sheraji, S. H., Ismail, A., Manap, M. Y., Mustafa, S., Yusof, R. M. A., and Hassan, F. A. (2011). Functional Properties and Characterization of Dietary Fiber from Mangifera pajang Kort. Fruit Pulp. *J. Agric. Food Chem*, 59**,** 3980–3985.
10. Anil, M. (2007). Using of hazelnut testa as a source of dietary fiber in breadmaking. *Journal of Food Engineering*, 80**,** 61-67.

11. AOAC. (2006). Official Methods of Analysis, 18th ed. Association of Official Agriculture Chemists, Washington D. C.
12. Artz, W. E., Warren, A. E., Mohring, A. E., and Villota, R. (1990). Incorporation of Corn Fiber into Sugar Snap Cookies. *Cereal chemistry*, 67(3), 303-305.
13. Ashoush, I. S. A., and Gadallah, M. G. E. (2011). Utilization of Mango Peels and Seed Kernels Powders as Sources of Phytochemicals in Biscuit. *World Journal of Dairy & Food Sciences*, 6(1), 35-42.
14. Beerh, O. P., Raghuramaiah, B., Krishnamurthy, G. V., and Giridhar, N. (1976). Utilization of mango waste: recovery of juice from waste pulp and peel. *J. Food Sci. and Tech*, 13, 138-141.
15. Bouaziz, M. A., Ben Amara, W., Attia, H., Blecker, C. A., & Besbes, S. (2010). Effect of the addition of defatted date seeds on wheat dough performance and bread quality. *Journal of Texture Studies*, 41**,** 511-531.
16. Brain, S. (2005). Sprout Damage in Cereal Grains and Falling Number assay. North Dakota University, Fargo.
17. Chen, H., Rubenthaler, G. L., Leung, H. K., and Baranowski, J. D. (1988). Chemical, physical, and baking properties of apple fibre compared with wheat and oat bran. *Cereal Chemistry*, 65**,** 244-247.
18. Criqui, M. H., and Ringel, B. L. (1994). Does diet or alcohol explain the French paradox? Lancet, 344, 1719-1723.
19. Ellis, P. (1985). Fiber and food products. Chapter 8 in: Dietary Fiber Perspectives Reviews and Bibliography. Leeds, A. R. and Avenell, A. eds. John Libbey and Company Limited : London.
20. FAO. (2009). Annual production of mango fruits in Egypt, at the web page: http://www.fao.org/faostat/.
21. Hassan, F. A., Ismail, A., Abdul Hamid, A., Azlan, A. A., and Al-Sheraji, S. H. (2011). Characterisation of fibre-rich

powder and antioxidant capacity of Mangifera pajang K. fruit peels. *Food Chemistry*, 126**,** 283–288.

22. Jang, J. S. R. (1993). “ANFIS: Adaptive-Network-Based Fuzzy Inference System*”*. In Man and Cybernetics*, IEEE Transactions on Systems,* 23, 665-685.
23. Kavdir, I., and Guyer, D. (2003) “Apple Grading Using Fuzzy Logic”, *Turk Journal Agric*, 27, 375-382.
24. Laurikainen, T., Harkonen, H., Autio, K., and Poutanen, K. (1998). Effects of enzymes in fiber-enriched baking. *J. Sci. Food Agric*, 76, 239–249.
25. Loelillet, D. (1994). The European mango market: A promising tropical fruit. Fruit, 49, 332-334.
26. Menrad, K. (2003). Market and marketing of functional food in Europe. *Journal of Food Engineering*, 56, 181–188.
27. Mir, S. A., Naik, H. R., Shah, M. A., Mir, M. M., Wani, M. H., and Bhat, M. A. (2014). Indian Flat Breads: A Review. *Food and Nutrition Sciences*, 5, 549-561.
28. Nehdi, I., Omri, S., Khalil, M. I., and Al-Resayes, S. I. (2010). Characteristics and chemical composition of date palm (Pheonix canariensis) seeds and seeds oil. *Industrial Crops and Products*, 32, 360-365.
29. Perrot, N., Me, L., Trystram, G., Trichard, J., and Deloux, M. (2003) “An Hybrid Approach Based On Fuzzy Logic and Genetic Algorithms To Control A Crossflow Microfiltration Pilot Plant”, Department of Food Engineering, *ENSIA-INRA*, 91305.
30. Platat, C., Habib, H. M., Almaqbali, F. D., Jaber, N. N. A., and Ibrahim, W. H. (2014). Identification of Date Seeds Varieties Patterns to Optimize Nutritional Benefits of Date Seeds. J Nutr Food Sci, S8: 008. doi:10.4172/2155-9600.S8-008.
31. Platat, C., Habib, H. M., Hashim, I. B., Kamal, H., Almaqbali, F., Souka, U. A., and Ibrahim, W. H. (2015).

Production of functional pita bread using date seed powder. *J Food Sci Technol*, 52(10), 6375-6384.

32. Pomeranz, Y., Shogren, M. D., Finney, K. F., Bechtel, D. B. A., and Grain Marketing, U. S. (1977). Fiber in breadmaking - Effects on functional properties. *Cereal Chemistry*, 54**,** 25-41.
33. Qarooni, J. (1990). Flat bread. American Institute of Baking Technical Bulletin. Vol. XII, Issue 12.
34. Qarooni, J., Moss, H. J., Orth, R. A. A., and Wootton, M. (1988). The effect of Flour properties on the quality of Arabic bread. *J.Cereal Sci*, 7**,** 95-107.
35. Qarooni, J., Orth, R. A. A., and Wootton, M. (1987). A test baking technique for Arabic bread quality. *J. Cereal Sci*, 6**,** 69-80.
36. Qarooni, J., Wootton, M. A., and Mcmaster, G. (1989). Factors Affecting the quality of arabic bread Additional Ingredients. *J. Sci. Food Agric*, 48**,** 235-244.
37. Quail, K. J., Mcmaster, G. A., and Wootton, M. (1991). Flat Bread Production. Food Australia, 43**,** 155-157.
38. Rosell, C. M., Rojas, J. A., and Benedito, C. (2001). Influence of hydrocolloids on dough rheology and bread quality. *Food Hydrocolloids*, 15(1), 75-81.
39. SAS. (2002). Statistical analysis system. User manual SAS/STAT 9 version. SAS institute Inc., NC, USA.
40. Schneeman, B. O. (1987). Soluble vs insoluble fibre – different physiological responses. *Food Technology*, 41**,** 81–82.
41. Sudha, M. L., Vetrimani, R. A., and Leelavathi, K. (2007). Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. *Food Chemistry*, 100**,** 1365-1370.
42. Toma, R. B., Orr, P. H., D'appolonia, B., Dintzis, F. R., and Tabekhia, M. M. (1979). Physical and chemical properties of

potato peel as a source of dietary fiber in bread. *J. Food Sci*, 44, 1403-1407.

43. Tsourveloudis, N., and Kiralakis, L. (2002) "Rotary Drying of Olive Stones: Fuzzy Modeling and Control", Department of Production Engineering and Management, Technical University of Crete, BA3015.
44. Vergara Valencia, N., Granados perez, E., Agama Acevedo, E., Tovar, J., Ruales, J., and Bello perez, L. A. (2007). Fiber concentrate from mango fruit: Characterization, associated antioxidant capacity and application as a bakery product ingredient. *LWT - Food Science and Technology*, 40**,** 722-729.
45. Wang, J., Rosell, C. M., and Barber, C. B. D. (2002). Effect of the addition of different fibres on wheat dough performance and bread quality. *Food Chemistry*, 79**,** 221–226.
46. Year Agriculture Statistical Book. (2013). Twenty six Issue. Ministry of Agriculture. Kingdom of Saudi Arabia, 6-290.

Table (1) Dough Rheological properties

Treatment	Con. (%)	Water absorption	DDT	Stability	M.T.I
control	**0**	57.8^{e} ±0.20	2.3^{ab} ±0.10	6.96^{e} ±0.01	25.7^{d} ±0.10
Mango Peel (MP)	**2**	58^{ed} ±0.01	2.3^{ab} ±0.10	10.17^{c} ±0.15	17^{e} ±1.00
	4	58.4^{cb} ±0.30	2.2^{b} ±0.01	10.27^{c} ±0.15	16.1^{e} ±1.1
Date Seed (DS)	**4**	58.7^{b} ±0.20	2.0^{c} ±0.01	9.27^{d} ±0.06	41.23^{a} ±0.11
	6	62.73^{a} ±0.25	2.33^{a} ±0.06	14.53^{a} ±0.06	30.6^{b} ±0.10
MIX (MP + DS)	**2 : 2**	58.2^{cd} ±0.10	2.02^{c} ±0.02	11.93^{b} ±0.06	27.33^{c} ±0.06

Within each column means with same letter(s) are not significantly different at P<0.05

The average results of triplicate and calculation based on 14 % moisture basis

Table (2) Effect of fiber sources on the tearing and folding properties of Arabic bread

Treatments (degree)	Conc. (%)	Rolling First day (10)	**Tearing First day (10)**	**Rolling Sec. day (20)**	**Tearing Sec. day (10)**
Control	0	8.96^{a} ±0.66	9.09^{a} ±0.73	18.86^{a} ±0.95	9.06^{a} ±0.78
Mango Peel (MP)	2	9.01^{a} ±0.85	9.09^{a} ±0.86	19.09^{a} ±0.61	9.05^{a} ±0.91
Mango Peel (MP)	4	8.82^{a} ±0.69	9.25^{a} ±0.72	16.66^{b} ±1.41	8.61^{ab} ±0.94
Date Seeds (DS)	4	8.17^{ab} ±0.96	8.75^{ab} ±1.16	16.90^{b} ±1.73	7.75^{b} ±1.26
Date Seeds (DS)	6	7.34^{b} ±0.89	7.99^{b} ±0.94	11.49^{c} ±2.08	6.34^{c} ±1.56
MIX (MP + DS)	2:2	9.11^{a} ±1.09	8.89^{ab} ±1.16	12.17^{c} ±2.10	6.56^{c} ±1.36

Within each column means with same letter(s) are not significantly different at P<0.05

Table (3): Validation Table

M	D	Day 1	Day 2	Actual RollFold	Predicted RollFold	RollFold Error%	Actual Tear	Predicted Tear	Tear Error%
0	0	1	0	8.65	9.00	5.14	8.56	9.13	6.65
0	0	1	0	8.67	9.00	3.80	8.67	9.13	5.30
0	0	0	1	17.33	19.20	10.80	7.67	9.51	24.00
0	0	0	1	18.00	19.20	6.70	9.67	9.51	4.40
2	0	1	0	10.00	9.00	10.00	9.67	9.24	4.40
2	0	1	0	8.67	9.00	3.80	10.00	9.24	7.60
2	0	0	1	19.00	19.10	0.50	9.00	9.08	0.90
2	0	0	1	19.33	19.10	1.20	10.00	9.08	9.20
4	0	1	0	8.17	9.24	13.00	9.33	9.32	0.10
4	0	1	0	7.67	9.24	20.00	8.00	9.32	16.50
4	0	0	1	16.00	16.90	5.60	8.33	8.71	4.50
0	4	1	0	10.00	7.98	20.00	9.00	8.56	4.90
0	4	1	0	8.33	7.98	4.20	8.00	8.56	7.00
0	4	0	1	19.33	16.40	15.00	9.00	7.67	14.80
0	4	0	1	17.00	16.40	3.50	8.00	7.67	4.10
0	6	1	0	8.67	7.14	17.60	8.00	8.15	1,90
0	6	0	1	10.00	11.80	18.00	6.0	6.33	5.50
2	2	1	0	9.00	9.12	1.30	8.00	9.00	12.50
2	2	0	1	14.67	11.80	19.60	8.00	6.28	21,50
2	2	0	1	12.00	11.80	1.70	7.00	6.28	10.30
				Average Absolute Percent Error		**9%**			**8%**

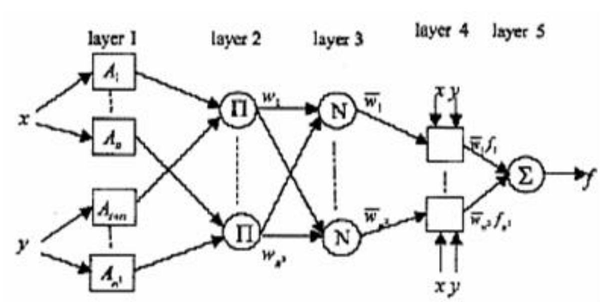

Figure (1): ANFIS Architecture

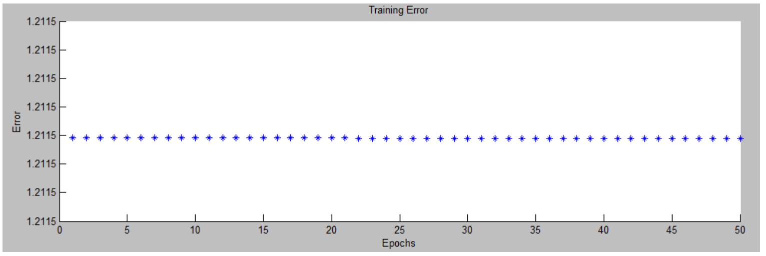

Figure (2): Learning curve of rolling/folding fuzzy system

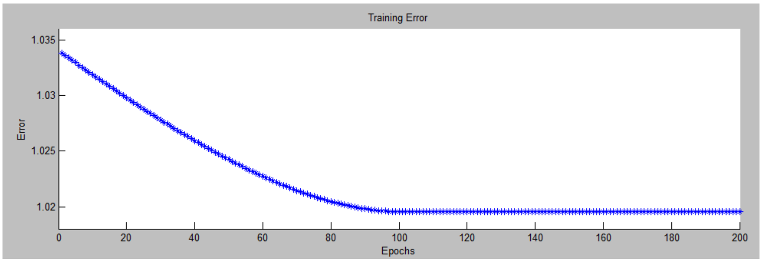

Figure (3): Learning curve of tearing fuzzy system

Figure (4): Actual and ANFIS-predicted values of rolling/folding values

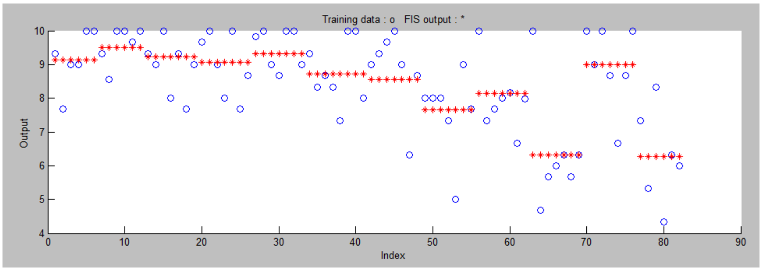

Figure (5): Actual and ANFIS-predicted values of tearing values

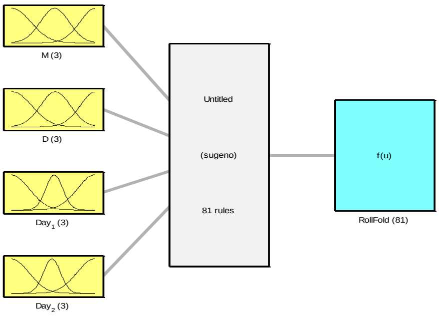

Figure (6): Fuzzy Inference System of the rolling/folding property

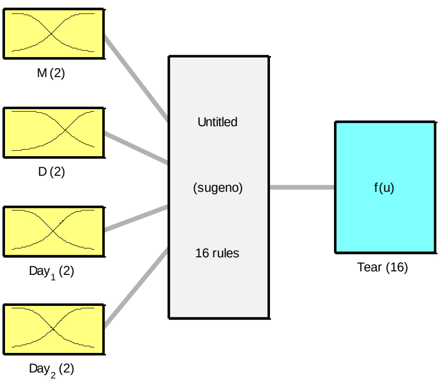

Figure (7): Fuzzy Inference System of the tearing property

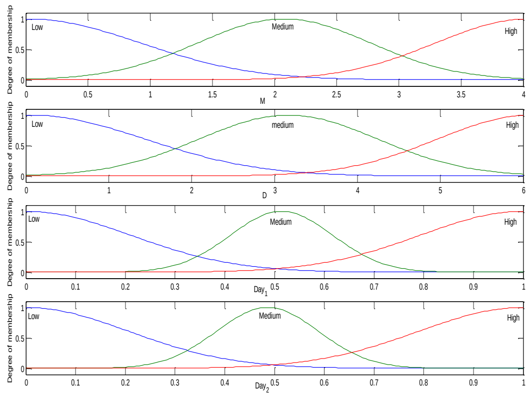

Figure (8): Final fuzzy membership functions for the rolling/folding property

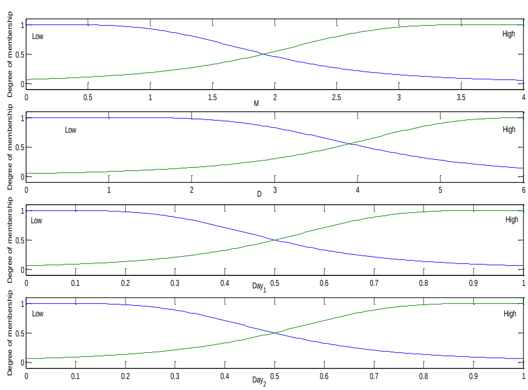

Figure (9): Final fuzzy membership functions for the tearing property

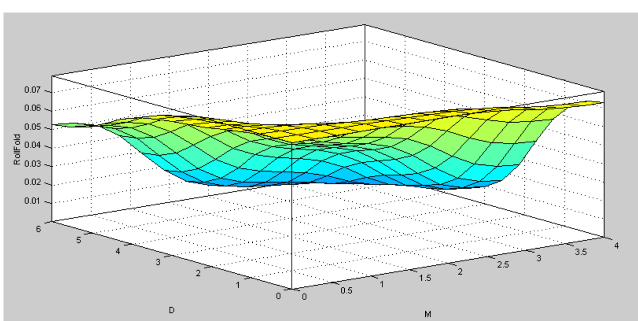

Figure (10): The final fuzzy-based prediction model of rolling/folding system

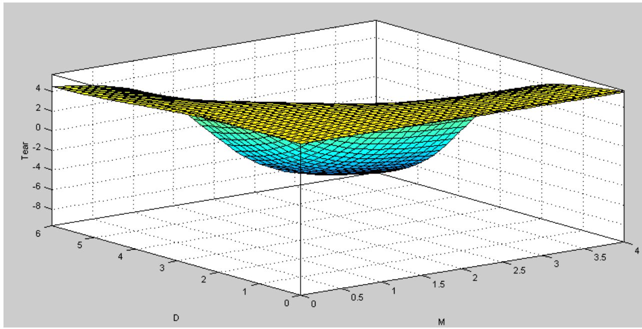

Figure (11): The final fuzzy-based prediction model of tearing system

Table (X1): Validation Table

M	D	Day 1	Day 2	Actual RollFold	Predicted RollFold	RollFold Error%	Actual Tear	Predicted Tear	Tear Error%
0	0	1	0	8.65	9.00	5.14	8.56	9.13	6.65
0	0	1	0	8.67	9.00	3.80	8.67	9.13	5.30
0	0	0	1	17.33	19.20	10.80	7.67	9.51	24.00
0	0	0	1	18.00	19.20	6.70	9.67	9.51	4.40
2	0	1	0	10.00	9.00	10.00	9.67	9.24	4.40
2	0	1	0	8.67	9.00	3.80	10.00	9.24	7.60
2	0	0	1	19.00	19.10	0.50	9.00	9.08	0.90
2	0	0	1	19.33	19.10	1.20	10.00	9.08	9.20
4	0	1	0	8.17	9.24	13.00	9.33	9.32	0.10
4	0	1	0	7.67	9.24	20.00	8.00	9.32	16.50
4	0	0	1	16.00	16.90	5.60	8.33	8.71	4.50
0	4	1	0	10.00	7.98	20.00	9.00	8.56	4.90
0	4	1	0	8.33	7.98	4.20	8.00	8.56	7.00
0	4	0	1	19.33	16.40	15.00	9.00	7.67	14.80
0	4	0	1	17.00	16.40	3.50	8.00	7.67	4.10
0	6	1	0	8.67	7.14	17.60	8.00	8.15	1,90
0	6	0	1	10.00	11.80	18.00	6.0	6.33	5.50
2	2	1	0	9.00	9.12	1.30	8.00	9.00	12.50
2	2	0	1	14.67	11.80	19.60	8.00	6.28	21,50
2	2	0	1	12.00	11.80	1.70	7.00	6.28	10.30
				Average Absolute Percent Error		**9%**			**8%**