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Rheological and Physochemical Properties of Lentil, Millet and whole Wheat Flour as a Composite Flour

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Abstract **– The consequences of mixture flour which contained four types of flour (lentil, millet, wheat flour and whole wheat flour) on dough rheology and biscuit quality were studied using mixture of two flours (wheat flour and whole wheat flour) and wheat flour (WF) as controls. Farinographic research showed that there were lower dough stability and dough development time in MIXF1 compared to that of the control MIXF2 but higher than WF. The higher water absorption was observed in MIXF2 which was 73.7% compared to MIXF1 which has 70%. The RVA of samples WF and MIXF2 demonstrated higher final viscosity, peak viscosity, setback and breakdown of pasting properties than the MIXF1 sample. The MIXF1 had the poorest peak viscosity, last viscosity, setback and breakdown. Foaming capacity (FC) and Emulsifying Capacity (EC) had been greater in MIXF1 than MIXF2 and WF.**

Keywords **– Lentil, Millet, Whole Wheat, Rheological Properties, Physochemical Properties.**

I. Introduction

Lentil (Lens culinaris Med. ssp. culinaris) is certainly indigenous to the Close to East and central Asia (Ladizinsky, 1979). (Barulina, 1930) in her traditional monograph on the Lentil has recommended that the cultivated lentils comes from the overland species Lens orientalis (Boiss.) Ponert among the initial domesticated crop plant in eastern Mediterranean area probably in eastern Turkey and northern Syria. This have been confirmed lately also by numerous molecular markers (Sharma, Knox, & Ellis, 1996). The raw lentils (Lens culinaris) nutrient composition per 100 g (USDA 2010) had been reported : energy kcal 353 (1,477 kJ), water 10.40 g, total fat 1.06 g, protein 25.80 g, carbohydrate 60.08 g, ash 2.67 g, total dietary fibre 30.5 g, total sugars 2.03 g, fructose 0.27 g, sucrose 1.47 g, maltose 0.30 g; Fe 7.54 mg, Ca 56 mg, Mg 122 mg, P 451 mg, Na 6 mg, K 955 mg, Cu 0.519 mg, Zn 4.78 mg, Mn 1.330 mg, Se 8.3 g, thiamine 0.873 mg, vitamin C 4.4 mg, niacin 2.605 mg, riboflavin 0.211 mg, pantothenic acid 2.140 mg, total folate 479 mg, vitamin B-6 0.540 mg, vitamin A 2 mcg RAE, total choline 96.4 mg, vitamin A 39 IU, b -carotene 23 mg, vitamin E 0.49 mg, vitamin K (phylloquinone) 5 mg, α-tocopherol 4.23 mg, total saturated essential fatty acids 0.156 g, 14:0 (myristic) 0.003 g, 16:0 (palmitic) 0.133 g, 18:0 (stearic) 0.015 g; 16:1 undifferentiated (palmitoleic) 0.003 g, 18:1 undifferentiated (oleic acid) 0.180 g, 20:1 (gadoleic) 0.006 g, total monounsaturated essential fatty acids 0.189 g, total polyunsaturated essential fatty acids 0.516 g, 18:3 undifferentiated (linolenic) 0.109 g, 18:2 undifferentiated (linoleic) 0.404 g.

The millets are various grass crops that are important in the semi-arid and sub-humid zones as staple crops for animals and human beings. Millets specifically proso millet (*Panicum miliaceum L.*) represent an fascinating crop given that they need less irrigation water to grow than any various other cereal (Winch, 2006). Proso millet, named common millet also, broom corn, hog millet, yellow hog, white millet and hershey (Baltensperger, 1996), as reported in Food and Agriculture Organization of the United Nations (Faostat, 2016), millet production all together including foxtail millet, pearl millet, proso millet, fonio millet, finger millet and others ranks 5th in world production figures, following corn, wheat, sorghum and barley. Within the last 11 years, millet production increased from 27 slightly. 6 million tonnes in 2000 to 31.6 million tonnes this year 2010, with a peak in 2008, where millet creation reached 34.9 million tonnes (Food, 2014). Suggested food applications for dehulled proso millet consist of as a puffed or prepared breakfast cereal or as an alternative for wheat flour in certain baked products and various other household recipes (Hinze, 1972).

Wheat (*Triticum sp.*) is an essential cereal crop and ranks third in production after rice and maize around the globe. It's the second most important winter season cereal in India after rice contributing sub-stantially to the nationwide food security by giving a lot more than 50% of the full total calorie consumption to the individuals who mainly depend onto it. The annual global wheat creation during the 12 months 2014-15 was 717 million metric tonnes and is approximated to attain 720 million metric tonnes during 2015-16, among which India is usually expected to create 95 million metric tonnes (Sharon, Abirami, & Alagusundaram, 2014). Wholegrain wheat flour all of the anatomical parts of the grain, such as endosperm, germ and bran can be found in the same proportions which exist in the intact type. Thus, wholegrain wheat flour contains more fibers substantially, vitamins, phytochemicals and minerals than refined wheat flour. Accordingly, it is regarded as an excellent way to obtain nutritional and functional elements for human wellness with many connected benefits, including the reduced amount of illnesses risk such as for example diabetes, cardiovascular diseases, weight problems, and cancer (Liu et al., 2007). However, of the health benefits regardless, WGWF could cause structural and sensory adjustments in food, resulting in lower customer acceptance. As a total result, there are troubles in producing WGWF meals that maintains the required functionality and quality equal to refined grain items (Bressiani et al., 2017). The aim of present study is to evaluate the physiochemical and rheological properties of lentil and millet flour based of whole wheat flour as composite flour.

II. Materials and Methods

A. Materials

Flours and the materials were supplied from Chinese markets. All chemicals, solvents and reagents had been of analytical grade.

B. Preparation of the Samples

The samples were prepared according to the previous work in paper not yet published as following: Firstly the composite flour (MIXF1) was contain lentil flour 22.5%, millet flour 11.5%, wheat flour 24% and whole wheat flour 42%. Secondly the mixture flours (MIXF2) it had been prepared by mixing two types of flour whole wheat flour 65.5% and wheat flour 34.5%. Thirdly just wheat flour (WF).

C. Bulk Density

The quantity of 100 g of the foodstuffs was measured in a measuring cylinder (250 mL) after tapping the cylinder on a wooden plank until no noticeable reduction in volume was noticed, and predicated on the volume and weight, the apparent (mass) density was calculated (Jones, Chinnaswamy, Tan, & Hanna, 2000; Krishnan, Dharmaraj, Manohar, & Malleshi, 2011).

D. Water Absorption Capacity and Water Solubility Index

One gram of every of the samples blended with 10 mL of distilled water was incubated for 30 min in water bath taken care of the temperature at 30 ^{0}C and also at 97 ^{0}C, centrifuged at 3500 rpm for 25 min and to calculate the water absorption capacity the excess weight of the residue had been noted (Bello, Tolaba, & Suarez, 2004). The supernatant transferred right into a pre-weighed petridish was evaporated on a water bath to dryness and dried in an air oven maintained at 105 ^{0}C for 5 h. the percentage soluble was calculated based on the dry weight of their residue (Stone & Lorenz, 1984).

E. Foaming Capacity (FC) and Foam Stability (FS)

Foam stability (FS) and Foam capacity (FC) of flours had been determined as described simply by (Kaur, Sandhu, Arora, & Sharma, 2015). In a graduated cylinder 1 g flour was put to 50 mL distilled water at 30 ± 2 ^{0}C. The suspension was combined and homogenized for 5 min (Ultra-turrax IKA T18 Basic, Wilmington, USA) to foam. The quantity was documented before and after whipping. FS was measured as % of the quantity increase because of whipping. The quantity of foam was recorded after 60 min whipping to determine FS as percent of the original foam volume.

F. Emulsion Activity

Emulsifying capacity was identified as described simply by (Zouari, Besbes, Ellouze-Chaabouni, & Ghribi-Aydi, 2016) with slight modification. Briefly, 1 g flour sample, 10 ml distilled water and sunflower oil 10 ml were ready and combined for 1 min using a (Ultra-turrax IKA T18 Basic, Wilmington, USA) homogenizer at 10,000 rpm to acquire an emulsion. Centrifuged for 5 min at 4,000 rpm. The ratio of the elevation of emulsion coating to the full total height of the combination was calculated as emulsion capability in percentage (Yasumatsu et al., 1972).

G. Swelling Capacity

Swelling capacity was analyzed as described simply by (Zouari et al., 2016) 100 mg of the various flours had been hydrated with 10 ml distilled water in a measuring cylinder at room heat, after 18 h, the quantity (ml) occupied had been authorized and swelling capacity (SC) was calculated as quantity ml/g of initial sample (Mateos-Aparicio, Mateos-Peinado, & Ruperez, 2010).

H. Dough Characteristics of the Composite Flour

1. Pasting Profiles

Pasting properties determination of flours had been utilizing a (Rapid Visco Analyser (RVA) model 4500, Perten Instruments, Australia) and the method described simply by (Krishnan et al., 2011). Flour 3 ± 0.01 g was put into the distilled water 25 ± 0.01 g in an aluminium RVA canister to secure a total continuous sample weight of 28 ± 0.01 g. The masses of the dH2O and flours were modified (±0.01 g) to compensate for the variations in moisture content of each sample. The moisture level in all the tests was maintained at 14%, Clumping was avoided by stirring with a plastic material paddle and pre-programmed profiles had been initiated. All the RVA tests had been carried out in triplicate.

2. Farinograph Measurements of Dough

Properties of dough were investigated utilizing a Farinograph-E (Brabender, Duisburg, Germany) according to a typical method mentioned by (Tong et al., 2010). The 300 g of every MIXF1, MIXF2 and WF basis on 14% moisture, mixing bowl was used and the combining was at the typical speed of 63 rpm at 30 °C, during mixing, water was added from the burette to provide a dough consistency of 500 BU, stability time, development time, degree of softening (12 minute after maximum), Water absorption, and mixing tolerance index of the samples had been recorded.

I. Statistical Analysis

The data were put through one-way analysis of variance (ANOVA) utilized the Statistical Package for the Social Sciences (SPSS, Version 20.0). Data are offered as means ± SD. Values had been acquired from triplicate determinations and the variations had been examined utilized the Duncan test, and a degree of $p \leq 0.05$.

III. Results and Discussions

A. Bulk Density

The majority density of flour expressed habitually on g/cm3 may be the density recorded beyond the impact of any compression (Chandra, Singh, & Kumari, 2015). The bulk density measurements were offered in Table 1. The BD of the various flours were ranged from 0.83 to 0.89 g/cm3. The BD was noticed significantly ($p \leq 0.05$) higher in WF (0.89 g/cm3) than in MIXF1 and MIXF2 (0.84

g/cm3) and (0.83 g/cm3) respectively it has been observed there is no significant differences between MIXF1 and MIXF2 in term of BD.

B. Water Absorption Capacity and Water Solubility Index

The product quality properties of flours play essential role in the developing of varied products. WF, MIXF1 and MIXF2 were analyzed for their quality properties (fig. 1).

Among the flour samples, WF showed the lowest WAC of 171.5% at 30°C whereas the highest was found for MIXF1 (188.48%) in 30°C, the MIXF2 showed WAC at 30°C (178.36%), while the WAC in 90°C, the WF was higher than MIXF1 and MIXF2 (777.02%), (590.08%) and (575.61%) respectively. The WAC of the samples significantly changed with the increase in temperature from 30 to 97°C. The water solubility of MIXF1 at 30°C was (8.67%) while that at 97°C was (13.38%). The MIXF2 was (7.01%) at 30 while it was (11.35%) in term of water solubility. On the other hand, the solubility of WF also increased with an increase in the temperature at 30°C (5.6%) and (6.53%) at 90°C (Malleshi, Desikachar, & Tharanathan, 1986).

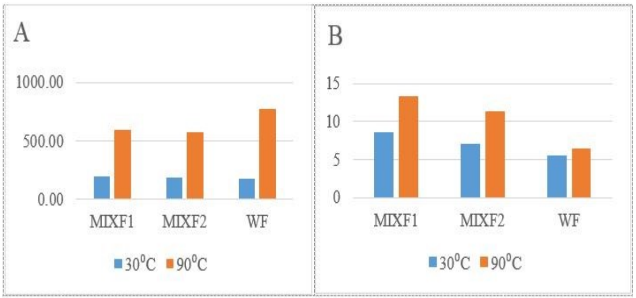


Fig. 1. Water absorption capacity (A), and water solubility index (B).

C. Foaming Capacity (FC) and Foam Stability (FS)

FC and FS of MIXF1, MIXF2 and WF differed significantly ($p < 0.05$, Table 1). FC for MIXF1, MIXF2 and WF was 97.24, 75.54 and 57.79% respectively. Significant reduction in FS was observed by incorporation of composite flour to WF. WF showed higher FS as compared to MIXF1, MIXF2. Whereas the lowest FS in MIXF1 which was 57.00% and the highest ratio of FS was in WF which was 67.5%.

Table 1. Functional properties of composite flour (COMF1), (COMF2) and wheat flour.

Test	COMF1	COMF2	WF
Bulk density(BD) g/cm^3	0.84^a±0.01	0.83^a±0.01	0.89^b±0.01
Foaming capacity (FC) %	97.24^c±0.06	75.55^b±0.05	57.51^a±0.53
Foam stability (FS) %	57^a±0.5	62.87^b±0.15275	62.87^c±0.26
Emulsion Capacity (EC) %	52.67^c±0.36	32.9^b ±0.36	12.5^a ±0.33
Swelling capacity (SC) ml/g	1.02a±0.01	1.02a±0.01	1.01a±0.01

Means in the same line with various characters are significantly varied (p 6 0.05) according to Duncan's multiple range test. Data expressed as mean ± S.D. of triplicate determinations.

D. Emulsion Capacity (EC)

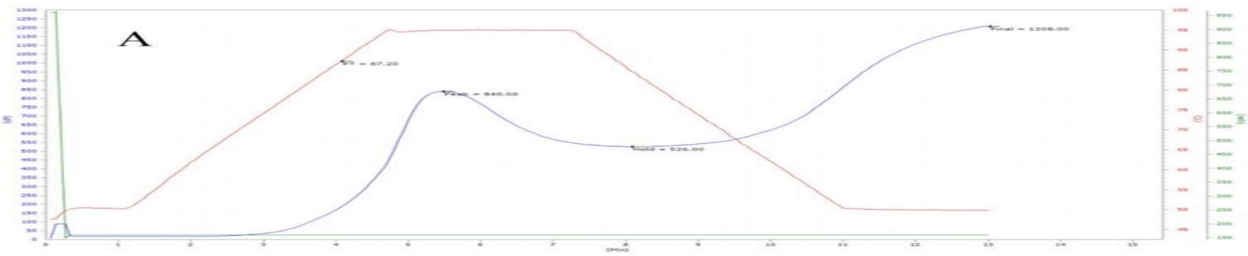
As presented in Table 1, Emulsifying Capacity (EC, %) of the various samples ranged between (12.5%), (32.9%) and (52.6%). The EC of composite flours improved considerably ($p \leq 0.05$) these findings are in relative with the outcomes reported by (Chandra et al., 2015). Interestingly, the EC documented for the MIXF1 reached 52.98% in these study, were greater than the EC found for MIXF2 and WF (32.9%) and (12.5%) respectively. Kaushal, Kumar, and Sharma (2012) reported that proteins become a surface energetic agents and stabilize the emulsion by carrying out electrostatic repulsion on essential oil droplet surface.

E. Swelling Capacity (SC)

The swelling capacity of the various samples ranged from 0.99 ml/g (wheat flour) to 0.98 ml/g (MIXF1 and MIXF2). From Table (1), it is clear that no changing on the swelling capacity by the incorporation of the addition of different flours. These outcomes were reverse of what has been reported by (Chandra et al., 2015) they reported that composite flours improved the swelling capacity with the increase in the amount of incorporation ratio of rice flour, potato flour and green gram flour and reduced with an increasing degree of wheat flour.

F. Pasting Profiles

Styles of the pasting house changes because of the alternative of different flours (lentil, millet, whole wheat grains) samples are presented in fig. 2. The RVA of samples WF and MIXF2 demonstrated higher peak viscosity, final viscosity, breakdown, and setback of pasting properties compared to the MIXF1 sample. As the MIXF1 had the littlest peak viscosity, breakdown, final viscosity and setback. Trough viscosity, final viscosity, breakdown and setback after warmth moisture treatment; as the pasting temperature could be improved depending on the procedure conditions (Puncha-arnon & Uttapap, 2013; Vilchis-Rodriguez & Acha, 2012).



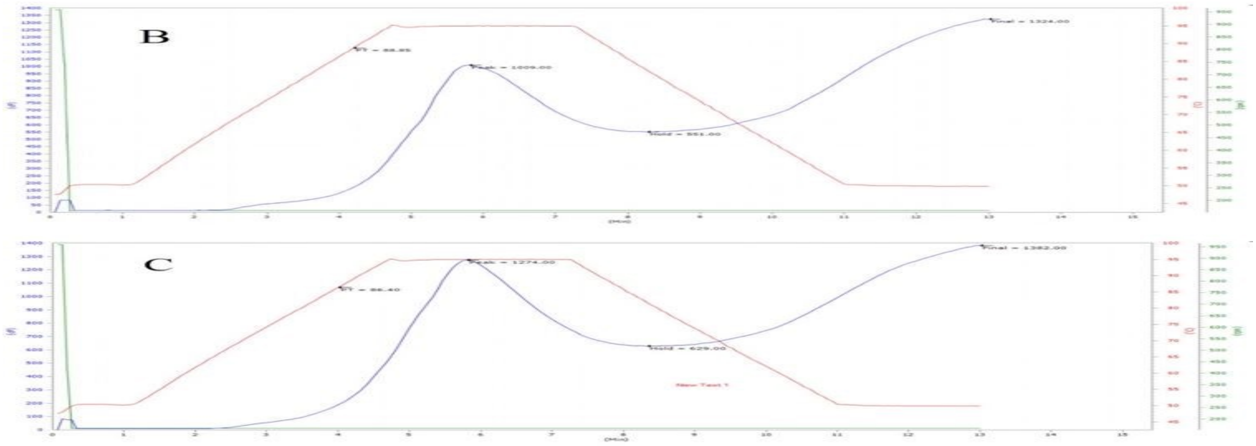
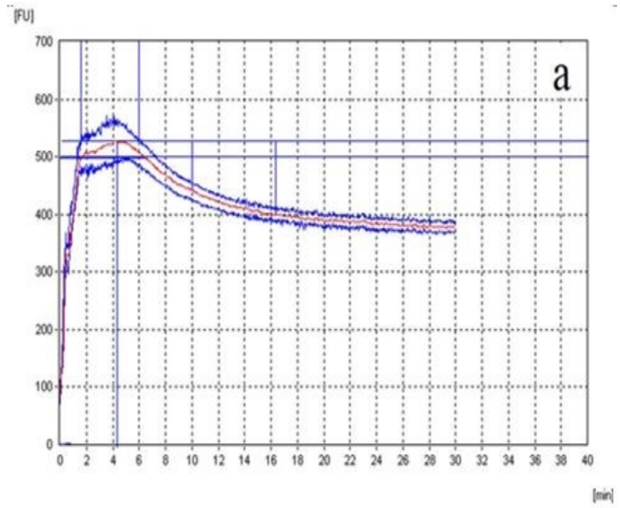
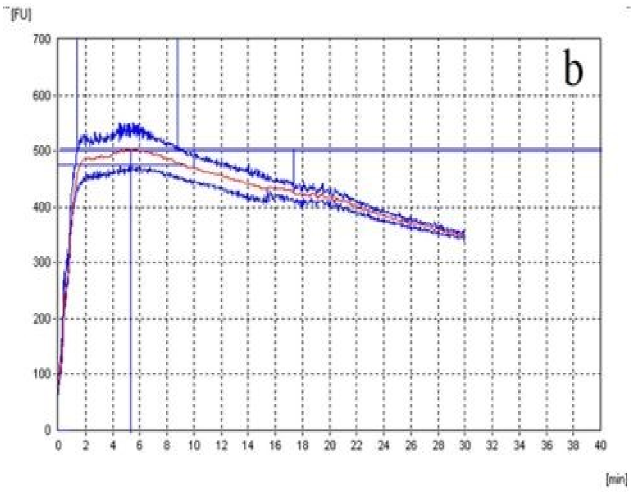


Fig. 2. Pasting profile of MIXF1 (A), MIXF2 (B) and WF (C)

G. Farinographic Characteristics

The farinographic characteristics of the samples are shown in fig. 3. Development time and the dough stability of MIXF1 was lower compared to that of the control MIXF2 but higher than WF. However, some modifications were seen in water absorption of the dough among the samples, where the water absorption of WF sample was 59.3%, the greater water absorption was observed in MIXF2 which was 73.7% compared to MIXF1 which has 70% in term of water absorption.





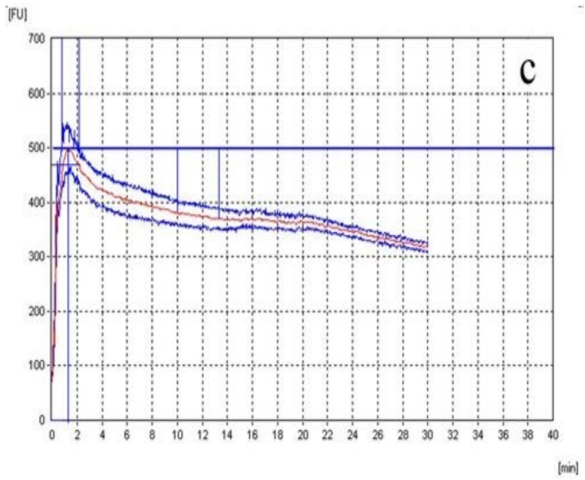


Fig. 3. Farinograph data of MIXF1 (a), MIXF2 (b) and WF doughs (c).

IV. Conclusion

This study showed that wheat flour could be substituted by lentil, millet, whole wheat flour, the result of rheological properties showed that the MIXF1 had the highest WAC compared to the control, while the BD was higher in WF sample, the MIXF1 was the higher in term of FC but was the lowest in FS, also MIXF1 was the greater in EC compared to MIXF2 and WF samples, no significant differences observed in term of SC among the samples. The RVA of samples WF and MIXF2 showed higher peak viscosity, breakdown, final viscosity and setback of pasting properties than the MIXF1 sample. The stability and dough development time of MIXF1 was lower in comparison to that of the control MIXF2 but higher than WF. The MIXF2 had a higher water absorption while the WF sample was the lowest in term of water absorption.

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