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# Effect of different starches on dough rheological properties of wheat flour

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**ABSTRACT**

Sudanese wheat flour (Imam) of 72% extraction rate, decorticated lentil flour and five starches from different local Sudanese cereal cultivars(wheat, sorghum, millet, rice) and cassava are used in this study. Ratios of starch used in wheat flour were 5%, 10% and 15%with 5%lentil flour. Flour characteristics and rheological properties were studied for wheat flour and wheat flour blends. The results indicated that addition of different starches blend resulted in an increase of falling number of wheat flour from 734.67 seconds to the range from 784.00 to 1079 seconds and significant decrease in wet gluten and gluten index. Addition of 5% and 10% millet starch blends resulted in increase in gluten index to 94.00 and 96.33 respectively. Water absorption decreased to the value ranged between 57.50 to 59.50% for 5% wheat, sorghum and cassava starches blends. Increased to 60.20% for 5% rice starch blend and decreased to the range between 55.70 to 58.40% for 10% and 15% wheat, sorghum, millet and cassava starches blends. Also increased to 61.50 and 63.80 for 10% and 15% rice starch blend respectively. Addition of high percentage of starch results in low values of dough development time. The energy and the extensibility of the dough of wheat flour decreased with addition of different starches percentages and the dough resistance to extension increased. Pasting temperature increased in the blends, while gelatinization temperature and gelatinization maximum decreased

***Keywords:*** *Extensograph, falling number, Farinograph, gluten, starch, wheat flour.*


## INTRODUCTION

Wheat is considered good source of protein, minerals, B-group vitamins and dietary fiber i.e. an excellent health-building food. Thus, it has become the principal cereal, being more widely used for bread making than any other cereal because of the quality and quantity of its characteristic protein called gluten. The gluten content is an important parameter in assessing the quality of wheat flour (Grabski , 1979; Kulkarni , 1987). The flour quality is mainly affected by the nature of the gluten and its various components. α-amylase is an inherent enzyme of wheat which converts starch into simple sugars (Bloksma and Bushuk, 1988).

Crandall (1996) reported that the lower the alpha- amylase activity of the flour, the higher the falling number reading, and vice versa. Badi (1978) observed that the falling number of Sudanese wheat was abnormally high, indicating the low alpha-amylase activity in the wheat. Ahmed (1995) reported that the falling number of some Sudanese wheat was found to be in the range of 397- 482 seconds for whole flour. Marchylo (1976) stated that the alpha- amylase of wheat affects the quality of wheat for bread. Rheological properties of dough are important to baker for two reasons; first, they determine the behavior of dough pieces during mechanical handling, such as dividing, rounding and molding. Second, they affect the quality of the finished loaf of bread. The rheological properties of the dough are determined by farinograph, mixograph, extensographetc (Austein and Ram, 1971). Farinograph is the most widely used to understand rheological behavior during dough mixing (Anonymous, 1990, and Pomeranz and Meloan, 1994). Farinograph is a recording dough mixer that measures torque needed for mixing dough at a constant speed and temperature. The resistance offered is integrated with time and traced on kymograph chart in form of curve. This curve is used to evaluate various rheological parameters such as dough development time, dough strength, dough stability etc. Anonymous, (1990).Farinograph is the most frequently used equipment for empirical rheological measurements (Razmi-Rad , 2007). DAppolonia (1976) reported that farinograph curve characteristics for any given wheat cultivar changes from location to location. The weather and soil conditions affect the protein content and wheat quality and indirectly the shape of the farinographic curve.

The composite flours containing wheat flour usually consisted of 70% wheat flour, 25% maize/cassava starch and 5% soy flour. But there were tests in which the composite flour contained no wheat flour at all for example 70% cassava flour or starch and 30% peanut and/ or soy flour. When starch is heated in water, it changes from a water insoluble material to a partially soluble and varies hydrophilic substance. As a result much of free water in starch water mixture becomes bound as the temperature increased. Starch acts as temperature triggered water sink in food system, the properties associated with the distribution of amylose and amylopectin within a granule are required for starch to function successfully in bread making (Hoseney , 1978). The objective of this study was to study the effect of starch on dough rheological properties of wheat flour.

## MATERIALS AND METHODS

Samples were brought from Agricultural Research Corporation. Chemicals and reagents were obtained from Food Research Center and local market.

***Preparation of starch:***

Wheat, Sorghum, Millet, Rice and Cassava were cleaned from impurities and foreign matter and prepared for extraction of starch by using Wet Milling process.

***Preparation of wheat flour and lentil flour:***

Wheat was cleaned manually for removing of impurities. Thesample of wheat was tempered for 17 hours to obtain 14.5% grain moisture, and then milled in a Chinese flour mill type (GFY-5) with the capacity of 5 tons/day**.** The flour was adjusted to 72% extraction rate by sifting using 180 micron sieve. The sample was well mixed and placed in air-tight plastic container, then stored under appropriate conditions (Deep freezer). Lentil (Abu Gibbaa) was decorticated using Stone Mill at Omdurman Local Market. The decorticated seeds were ground into flour using an efficient universal pulverizer, (GF 300, serial number 69578, and powder fineness 90 – 120 mesh – Shanghai).

***Preparation of Composite Flour Blends:***

The starch of each sample of wheat, sorghum, millet, rice and cassava was added to wheat flour with three different percentages 5%, 10% and 15%with5% of lentil flour added to each of the three blends.

***Rheological characteristics of dough:***

***Gluten Content:***

The gluten content was determined according to the standard ICC method (1982) and by the use of gluten washing machine (using Glutamatic type 2200).

***Alpha amylase activity:***

The alpha amylase activity was determined according to the falling Number Method of Perten (1996). The corrected weight of sample based on 14% moisture was weighed and transferred into viscometer tubes (using Apparatus of falling Number type 1800).

***Farinograph of dough:***

The rheological properties of the dough prepared from wheat flour and wheat flour blends were measured using the Brabender farinograph method (Brabender OHG, Kulturte, 51-55, D-4055, Duisburg, Germany) according to the method of AACC (1999).

***Extensograph characteristics:***

The dough extensibility was determined by using the Brabenderextensograph according to the standard method of the AACC No. 54 – 10 (1999).

***Amylograph of wheat flour and wheat flour blends:***

Gelatinization of wheat flour and wheat flour blends was determined by using the brabender GmbH and Co. KG amylograph-E (Kulturstr. 51-55 D-47055 Duisburg, Type 800150, No- 080085, model 2008) according to the standard method of A.A.C.C (2000).

***Method of statistical analysis***

The data were statistically analyzed by the Completely Randomized Designasdescribed by Montgomery ((2001) and the mean differences were tested by Duncan Multiple Range Test (DMRT).

## RESULTS AND DISCUSSION

***Falling number of wheat flour and wheat flour containing starches blends:-***

The falling number values of wheat flour extraction rate 100% and 72% are shown in table (1).Whereas tables (2), (3) and (4) showed the falling number values of wheat flour containing 5%, 10% and 15% starch with 5% lentil flour.

The falling number values of wheat flour extraction rate 100% and 72% was found to be 618.67 and 734.67 seconds respectively. Statistical analysis showed highly significant differences between the two extraction rates. Addition of wheat, sorghum, millet, rice and cassava starches blends increased the values of the falling number to the range between 784 and 1079 seconds. Also statistical analysis showed highly significant differences between all the ratios of starches blends. Form the results obtained, it could be observed that the values of falling number for different blends of starch were relatively high (low alpha -amylase) and all of the blends were higher than the falling number of wheat flour, that may be attributed to the increase of level of starch in the blends. These results are in agreement with the data reported by Hassan (2007) and Badi , (1978) who observed that the falling number of Sudanese wheats was abnormally high, indicating the low alpha- amylase activity in the wheat. Alpha-amylase may be added to wheat flour to achieve any desired level of enzyme activity. The optimum level of enzyme activity is ultimately governed by the end use of the flour and the type of processing involved in the end use, as mentioned by Mailhot and Patton (1988).

***Gluten quantity and quality of wheat flour and wheat flour containing starches blends:***

Wet gluten and gluten index values of wheat flour extraction rate 100% and 72% were shown in table (1), whereas tables (2), (3) and (4) showed the wet gluten and gluten index of wheat flour blends. Wet gluten of wheat flour extraction rate 100% and 72% was 34.18 and 35.10% respectively. Gluten index of wheat flour extraction rate 100% and 72% were 82.00 and 91.67% respectively. Addition of starch blends in wheat flour resulted in significant decrease in wet gluten to the range between 26.57 and 33.13%. Statistical analysis of the results showed significant difference between blends in their wet gluten. The high value of wet gluten was observed in 5% wheat starch blend, while the low value was in 15% wheat starch blend. These results are comparable with results reported by Hassan (2007), Ahmed (2005), Kulkarni (1987) and Mohammed (2000). Ahmed (2013) obtained values from 30.87 to 33.13% wet gluten for different wheat flour blends. Addition of wheat, sorghum, rice and cassava starches to wheat flour resulted in a significant decrease in gluten index to the range between 71.00 and 91.33%. Analysis of variance showed highly significant difference in the ratio of 5% and 15% starches blends in their gluten index, on the other hand showed significant difference in10% starches blends in their gluten index.

Table 1. Falling number (sec.) and gluten content (%) of wheat flour extraction rates (100% and 72%)

| Wheat Flour | Falling number (sec) | Gluten content | |
|---|---|---|---|
| | | Wet gluten (%) | Gluten index(%) |
| Wheat flour (100%) | 618.67±8.02[b] | 34.18±0.05[b] | 82.00±1.00[b] |
| Wheat flour (72%) | 734.67±8.50[a] | 35.10±0.10[a] | 91.67±0.58[a] |
| $Lsd_{0.05}$ | 96.2514** | 0.8275* | 8.6733* |
| SE± | 17.8256 | 0.0413 | 1.0189 |

Values are mean ± SD.

Any two mean value(s) having the same superscript(s) in a column are not differerent significantly (P≤0.05).

NS = not significant * = significant ** = highly significant

Table 2. Falling number (sec) and gluten content (%) of wheat flour containing 5% of wheat, sorghum, millet, rice and cassava starches with5% lentil Flour

| Wheat Flour Blends+ 5% lentil flour | Falling number(sec) | Gluten content Wet gluten (%) | Gluten index (%) |
|---|---|---|---|
| 5% wheat starch | 838.30±3.51$^{b}$ | 33.13±0.12$^{a}$ | 78.33±0.58$^{d}$ |
| 5% sorghum starch | 833.70±5.69$^{b}$ | 32.37±0.12$^{bc}$ | 91.33±1.53$^{b}$ |
| 5% millet starch | 981.30±5.51$^{a}$ | 31.70±0.17$^{d}$ | 94.00±1.00$^{a}$ |
| 5% rice starch | 808.00±5.57$^{c}$ | 32.53±0.15$^{b}$ | 87.67±0.58$^{c}$ |
| 5% cassava starch | 784.00±4.00$^{d}$ | 32.17±0.06$^{c}$ | 87.67±1.15$^{c}$ |
| $Lsd_{0.05}$ | 8.987** | 0.2372* | 1.879** |
| SE± | 2.852 | 0.07528 | 0.5964 |

Values are mean±SD.
Any two mean value(s) having the same superscript(s) in a column are not different significantly (P≤0.05).
NS = not significant * = significant ** = highly significant

Table 3. Falling number (sec) and gluten content (%) of wheat flour containing 10% of wheat, sorghum, millet, rice and cassava starches with5% lentil Flour

| Wheat Flour Blends+ 5% lentil flour | Falling number(sec) | Gluten content Wet gluten (%) | Gluten index (%) |
|---|---|---|---|
| 10% wheat starch | 1011.00±9.50$^{b}$ | 30.53±0.15$^{a}$ | 82.67±0.58$^{d}$ |
| 10% sorghum starch | 1053.00±7.02$^{a}$ | 28.60±0.10$^{a}$ | 90.67±0.58$^{b}$ |
| 10% millet starch | 987.70±6.11$^{c}$ | 27.47±0.15$^{a}$ | 96.33±0.58$^{a}$ |
| 10% rice starch | 1020.00±4.00$^{b}$ | 28.07±0.21$^{a}$ | 85.00±1.00$^{c}$ |
| 10% cassava starch | 847.00±4.36$^{d}$ | 29.70±0.10$^{a}$ | 85.67±1.15$^{c}$ |
| $Lsd_{0.05}$ | 11.85** | 0.2698* | 1.486* |
| SE± | 3.759 | 0.08563 | 0.4715 |

Values are mean±SD.
Any two mean value(s) having the same superscript(s) in a column are not different significantly (P≤0.05).
NS = not significant * = significant ** = highly significant

Table 4. Falling number (sec) and gluten content (%) of wheat flour containing15% of wheat, sorghum, millet, rice and cassava starches with5% lentil Flour

| Wheat Flour Blends+ 5% lentil flour | Falling number(sec) | Gluten content Wet gluten (%) | Gluten index (%) |
|---|---|---|---|
| 15% wheat starch | 1079.00±6.11$^{a}$ | 26.57±0.12$^{c}$ | 86.33±1.53$^{c}$ |
| 15% sorghum starch | 1076.00±4.58$^{a}$ | 27.07±0.15$^{b}$ | 89.67±1.53$^{bc}$ |
| 15% millet starch | 1052.00±5.86$^{b}$ | 27.27±0.12$^{b}$ | 94.67±3.79$^{a}$ |
| 15% rice starch | 891.30±4.16$^{c}$ | 27.63±0.06$^{a}$ | 71.00±1.00$^{d}$ |
| 15% cassava starch | 825.70±4.51$^{d}$ | 27.20±0.10$^{b}$ | 90.33±1.15$^{b}$ |
| $Lsd_{0.05}$ | 9.288** | 0.2074* | 3.758** |
| SE± | 2.948 | 0.06583 | 1.193 |

Values are mean±SD.
Any two mean value(s) having the same superscript(s) in a column are not different significantly (P≤0.05).
NS = not significant * = significant ** = highly significant

It was observed that higher values of gluten index were obtained from the blends of millet starch when compared with other starches. These values agreed with the results obtained by Ahmed (2013) and Hassan (2007). The decreasing level of wet gluten was attributed to the dilution effect of starch in wheat flour and the high gluten index of millet starch blends may be attributed to the protein content of millet starch when compared to other starches.

Farinograms of doughs prepared from wheat flour and composite flour blends:-

The farinograph behavior of doughs made from wheat flour and the various composite flour blends is presented in tables (5), (6) and (7)). Water absorption value for control wheat flour was 59.70%, this value decreased to 57.50, 59.50 and 58.10% for 5% wheat, sorghum and cassava starches blends respectively and increased to 60.20% for 5% rice starch blend. Water absorption value for 5% millet starch blend was same as wheat flour 59.70%. The value of water absorption of wheat flour decreased to 57.50, 56.90, 55.80 and 58.10% for 10% wheat, sorghum, millet and cassava starches blends and decreased to 55.70, 57.00, 58.10 and 58.40% for 15% wheat, sorghum, millet and cassava starches blends respectively. This value of water absorption of control wheat flour increased to 61.50 and 63.80% for 10% and 15% rice starch blend respectively. The results were supported by the results obtained by Hassan (2007) and Sulieman (2005). Decreasing of water absorption values in blends could be attributing to the lower water absorption capacity and decreasing levels of protein content caused by starch. Dough development time for wheat flour (control) was 4.00 minutes. The blends gave values ranged from 4.00 to 4.70 minutes for 5% starches blends, 1.70 to 3.70 minutes for 10% starches blends and 1.20 to 3.70minutes for 15% starches blends. However, dough development time for wheat flour increased to 4.30, 4.70 and 4.20 for 5% wheat, millet and rice starches blends respectively, and decreased in 10% and15% starches blends. 5% sorghum starch blend and 5% cassava starch blend gave the same results of dough development time similar to control.

Addition of high percentages of starch (10%and 15%) resulted in low values of dough development time. This followed the general trends reported by Anaka and Tipples (1979) who reported that dough development time increased in flours with high protein content. The dough stability time of wheat flour (control) value was 5.60 minutes tended to decrease with addition of 5%, 10%and 15% starches blends to the ranges between 4.90 to 5.20minutes for 5% starch blends, 4.80 to 5.10minutes for 10% starch blends and 4.20 to 5.50 minutes for 15% starch blends respectively. The dough stability time of 10% millet starch blend was the same as the control wheat flour. The lowest dough stability time was observed in 15% sorghum, rice and cassava starches blends, while the highest value was in wheat flour (control) and 10% millet starch blend. The same result was obtained by Hassan (2007).

Table 5. Farinograms Characteristics of wheat flour containing 5%of wheat, sorghum, millet, rice and cassava starcheswith 5% lentil flour

| Flour blends + 5% lentil flour | Farinograph readings Water absorption % | Dough development time (min.) | Dough stability (min.) | Degree of softening (F.U.) | Farinograph quality number |
|---|---|---|---|---|---|
| Wheat flour (control) | 59.7 | 4.0 | 5.6 | 91 | 66 |
| 5% wheat starch | 57.5 | 4.3 | 5.2 | 63 | 70 |
| 5% Sorghum starch | 59.5 | 4.0 | 5.0 | 91 | 62 |
| 5% Millet starch | 59.7 | 4.7 | 4.9 | 91 | 61 |
| 5% Rice starch | 60.2 | 4.2 | 4.9 | 90 | 60 |
| 5% Cassava starch | 58.1 | 4.0 | 5.1 | 70 | 67 |

Table 6. Farinograms Characteristics of wheat flour containing 10%of wheat,sorghum, millet, rice and cassava starches with 5% lentil flour

| Flour blends + 5% lentil flour | Farinograph readings Water absorption % | Dough development time (min.) | Dough stability (min.) | Degree of softening (F.U.) | Farinograph quality number |
|---|---|---|---|---|---|
| Wheat flour (control) | 59.7 | 4.0 | 5.6 | 91 | 66 |
| 10% wheat starch | 57.5 | 3.5 | 5.0 | 85 | 60 |
| 10% Sorghum starch | 56.9 | 1.7 | 4.9 | 69 | 58 |
| 10% Millet starch | 55.8 | 3.5 | 5.6 | 82 | 71 |
| 10% Rice starch | 61.5 | 3.7 | 4.8 | 86 | 64 |
| 10% Cassava starch | 58.1 | 1.7 | 5.1 | 65 | 63 |

Table 7. Farinograms Characteristics of wheat flour containing 15%of wheat, sorghum, millet, rice and cassava starches with 5% lentil flour

| Flour blends + 5% lentil flour | Farinograph readings Water absorption % | Dough development time (min.) | Dough stability (min.) | Degree of softening (F.U.) | Farinograph quality number |
|---|---|---|---|---|---|
| Wheat flour (control) | 59.7 | 4.0 | 5.6 | 91 | 66 |
| 15% wheat starch | 55.7 | 3.5 | 5.5 | 71 | 63 |
| 15% Sorghum starch | 57.0 | 1.7 | 4.2 | 75 | 49 |
| 15% Millet starch | 58.1 | 1.2 | 4.4 | 70 | 51 |
| 15% Rice starch | 63.8 | 3.7 | 4.2 | 111 | 55 |
| 15% Cassava starch | 58.4 | 1.4 | 4.2 | 76 | 50 |

The degree of softening for control wheat flour was 91.00 F.U. The lowest degree of softening value 63.00 F.U. was observed in 5% wheat starch blend, while the highest degree of softening111.00 F.U. was observed in 15% rice starch blend. The farinograph quality number values decreased gradually from 66.00 minutes for wheat flour (control) to 62.00, 61.00 and 60.00 minutes for 5% sorghum, millet and rice starches blends and to 60.00, 58.00, 64.00 and 63.00 minutes for 10% wheat, sorghum, rice and cassava starches blends and to 63.00, 49.00, 51.00, 55.00 and 50.00 minutes for 15% wheat, sorghum, millet, rice and cassava starches blends respectively. Also this value increased to 70.00, 67.00 and 71.00 minutes for 5% wheat and cassava starches blends and 10% millet starch blend respectively. These results were in agreement with the results obtained by Hassan (2007).Mohammed (2000) reported that the water absorption for Sudanese cultivars ranged from 57.50% to 61.00%; also he found that dough development time, dough stability and degree of softening were 3.00 to 5.00 minutes, 1.00 to 3.50 minutes and 40.00 to 70.00 F.U. respectively.

Anaka and Tipples (1979) reported that high water absorption gives more stability curve and long development time. Hamada (1982) and Bietz (1986) showed that the mixing strength is correlated with dough stability and the dough stability also showed an increase with increase in gluten content. Meredith (1967) reported that the dough development time ranged between 3.00 and 6.00 minutes.

***Extensograms characteristics of the doughs prepared from wheat flour and composite flour blends:***

The extensogram characteristics of the doughs prepared from wheat flour (control) and wheat flour with different blends of starch is shown in tables (8), (9) and (10). The extensogram measures the extensibility (E) (mm), the energy ($cm^2$), the resistance (BU) and the resistance to extension (R/E) (BU). From the results obtained, the energy of the dough (dough strength) and the dough extensibility were decreased with increasing of level of starch in wheat flour blends. From these results it could be observed that dough energy and extensibility decreased with increasing level of starch in blends, dough resistance to extension decreased at low level (5%) and then increased with increasing level of starch and maximum resistance increased with increased level of starch when the time increased to 135 minutes. The dough resistance (maximum dough) (BU) was decreased for 5% starches blends, increased for 10% wheat, sorghum, millet and cassava starches blends after 135 minutes and for 15% wheat, sorghum, millet and cassava starches blends respectively. Energy, resistance to extension, extensibility and maximum dough resistance decreased in all blends of rice starch. In general these agreed with the findings of Jone (1991) and Hassan (2007).

Table 8. Extensograms characteristics of wheat flour containing 5% of wheat, sorghum, millet, rice and cassava starcheswith 5% lentil flour

| Flour blends+ 5% lentil flour | Energy ($cm^2$) | | | Resistance to extension (BU) | | | Extensibility (mm) | | | Maximum Resistance (BU) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 min. | 90 min. | 135min. | 45min. | 90min. | 135min. | 45min. | 90min. | 135min. | 45min. | 90min. | 135 min. |
| Wheat flour (control) | 115 | 116 | 106 | 395 | 445 | 431 | 160 | 148 | 142 | 510 | 571 | 538 |
| 5% wheat starch | 93 | 85 | 83 | 386 | 426 | 444 | 143 | 126 | 120 | 441 | 470 | 483 |
| 5% sorghum starch | 85 | 79 | 83 | 308 | 353 | 386 | 157 | 137 | 133 | 365 | 396 | 430 |
| 5% millet starch | 84 | 82 | 83 | 325 | 348 | 379 | 150 | 139 | 135 | 371 | 401 | 427 |
| 5% rice starch | 77 | 73 | 74 | 328 | 351 | 370 | 143 | 131 | 128 | 343 | 368 | 388 |
| 5% cassava starch | 93 | 93 | 93 | 409 | 408 | 487 | 139 | 140 | 123 | 455 | 458 | 528 |

Table 9. Extensograms characteristics of wheat flour containing 10% of wheat, sorghum, millet, rice and cassava starches with 5% lentil flour

| Flour blends+ 5% lentil flour | Energy ($cm^2$) | | | Resistance to extension (BU) | | | Extensibility (mm) | | | Maximum Resistance (BU) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 min. | 90 min. | 135 min. | 45 min. | 90 min. | 135 min. | 45 min. | 90 min. | 135 min. | 45 min. | 90 min. | 135 min. |
| Wheat flour (control) | 115 | 116 | 106 | 395 | 445 | 431 | 160 | 148 | 142 | 510 | 571 | 538 |
| 10% wheat starch | 86 | 81 | 87 | 398 | 467 | 524 | 132 | 113 | 112 | 431 | 495 | 547 |
| 10% sorghum starch | 93 | 89 | 82 | 421 | 514 | 546 | 134 | 115 | 104 | 457 | 537 | 559 |
| 10% millet starch | 101 | 4 | 93 | 561 | 321 | 737 | 115 | 4 | 92 | 583 | 1147 | 744 |
| 10% rice starch | 62 | 63 | 64 | 307 | 330 | 302 | 127 | 122 | 130 | 307 | 330 | 315 |
| 10% cassava starch | 77 | 88 | 86 | 392 | 458 | 510 | 124 | 123 | 112 | 410 | 485 | 542 |

Table 10. Extensograms characteristics of wheat flour containing 15% of wheat, sorghum,millet, rice and cassava starches with 5% lentil flour

| Flour blends+ 5% lentil flour | Energy ($cm^2$) | | | Resistance to extension (BU) | | | Extensibility (mm) | | | Maximum Resistance (BU) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 min. | 90 min. | 135 min. | 45 min. | 90 min. | 135 min. | 45 min. | 90 min. | 135 min. | 45 min. | 90 min. | 135 min. |
| Wheat flour (control) | 115 | 116 | 106 | 395 | 445 | 431 | 160 | 148 | 142 | 510 | 571 | 538 |
| 15% wheat starch | 75 | 86 | 95 | 446 | 508 | 554 | 111 | 113 | 113 | 450 | 521 | 583 |
| 15% sorghum starch | 83 | 83 | 84 | 446 | 518 | 565 | 119 | 107 | 102 | 461 | 534 | 584 |
| 15% millet starch | 104 | 89 | 80 | 578 | 610 | 648 | 119 | 100 | 88 | 590 | 625 | 651 |
| 15% rice starch | 54 | 51 | 46 | 270 | 260 | 243 | 129 | 130 | 128 | 271 | 261 | 244 |
| 15% cassava starch | 85 | 86 | 84 | 436 | 488 | 522 | 123 | 114 | 106 | 449 | 513 | 545 |

***Effect of starches on amylograph properties of wheat flour:***

Amylograph of wheat flour and wheat flour blends is shown in table (11). Pasting temperature of wheat flour (beginning of gelatinization) was 63.90 C°, gelatinization temperature was 91.30 C° and gelatinization maximum (viscosity in Amylograph unit) was1625 AU. Addition of different starches blends with different percentages 5, 10 and 15% resulted in increasing of pasting temperature to the range from 64.10to 64.80 C° for 5% starches blends, 64.10 to 64.60 C° for 10% starches blends and to the range from 64.00 to64.90 C° for 15% sorghum, millet, rice and cassava starches blends respectively. Pasting temperature was decreased to 63.80 C° in 15% wheat starch blend. Gelatinization temperature was decreased to the range between 90.40 to 90.90 C° for 5% wheat, sorghum, millet, rice and cassava starches blends respectively and to the range from 89.40 to 90.40 for 10% wheat, sorghum, millet and cassava starches blends respectively and to the range from 88.80 to 91.10 C° for 15% starches blends. Gelatinization maximum (viscosity) decreased to 1611; 1551and 1604 AU for 5%, 10% and 15% rice starch blends respectively. Generally it could be concluded that pasting temperature of wheat flour increase with the addition of different starches blends percentages. Gelatinization temperature decreased in all percentages of starch blending except for 10% rice starch blend. Viscosity value in Amylograph unit of rice starch blends with different percentages was lower than wheat flour. These results were comparable with the results obtained by Ghiasi (1982). Yaseen and Shouk (2011) found that replacing wheat flour using corn starch at different levels increased all measured parameters of dough rheological evaluated by viscoamylograph. Shuey (1975) reported that higher amylograph values indicate less amylase activity and conversely lower amylogram values indicate higher activity, extremely low values or high activity will cause slackening of the dough, especially during fermentation. The amount of slackening depends on the starch damage of the flour.

Table 11. Amylograph evaluation of wheat flour and wheat flour containing 5, 10, and 15% different starches with 5% lentil flour

| Type of flour blends+ 5% lentil flour | Beginning of Gelatinization (Cº) | Gelatinization Temperature (Cº) | Gelatinization maximum (AU) |
|---|---|---|---|
| Wheat flour | 63.90 | 91.30 | 1625 |
| 5% wheat starch | 64.10 | 90.40 | 1687 |
| 5% sorghum starch | 64.80 | 90.90 | 1678 |
| 5% millet starch | 64.40 | 90.40 | 1774 |
| 5% rice starch | 64.30 | 90.60 | 1611 |
| 5% cassava starch | 64.10 | 90.40 | 1644 |
| 10% wheat starch | 64.60 | 90.00 | 1848 |
| 10% sorghum starch | 64.50 | 90.10 | 1815 |
| 10% millet starch | 64.60 | 90.40 | 1732 |
| 10% rice starch | 64.50 | 91.30 | 1551 |
| 10% cassava starch | 64.10 | 89.40 | 1678 |
| 15% wheat starch | 63.80 | 90.90 | 1800 |
| 15% sorghum starch | 64.90 | 88.80 | 1962 |
| 15% millet starch | 64.80 | 90.30 | 1856 |
| 15% rice starch | 64.00 | 91.10 | 1604 |
| 15% cassava starch | 64.40 | 89.60 | 1755 |

### *Conclusion*

- Falling number increase while the gluten quantity and quality, and the dough rheology characteristics decrease as a result of the addition of starch to the wheat flour blends.
- The pasting temperature of blends increase, whereas gelatinization temperature and gelatinization maximum decrease.
- Water absorption of rice starchblends was high compare to control, while dough development time decrease with increasing level of starch in the blends.
- Energy of the dough and the dough extensibility decreased with increasing level of starch in the blends.

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