Effect of Substitution Sweet Potato Flour on the Rheological and Technological Properties of Balady Bread

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Abstract

This study investigated the effects of partial wheat flour (72% extraction) substitution with sweet potato flour (SPF) (10-40%) on the rheological, nutritional, and sensory properties of Egyptian balady bread. Farinograph and Extensograph analyses revealed that SPF incorporation progressively reduced water absorption (59.5% to 57%), dough stability (14.0 to 3 min), and extensibility (170 to 63 mm), while increasing resistance to extension (280 to 834 BU), indicating gluten network disruption. Wet gluten content decreased significantly (32.58 to 14.5 g), though gluten index remained >80% at all substitution levels. Nutritionally, Sweet potato flour increased protein (15.71% to 19.24%), dietary fiber (41.11%), and carotenoid content compared to control. Sensory evaluation showed that ≤20% SPF blends-maintained acceptability (88.80/100 vs. 92.10 for control), Higher substitutions (30-40%) performed poorly in texture ,crust color, and overall quality (72.25-60.65/100).The study concludes that 10-20% SPF substitution optimally enhances nutritional value without compromising bread quality, whereas higher levels require technological interventions to mitigate rheological deterioration.

Keywords: Sweet potato flour, balady bread, gluten index, farinograph, sensory evaluation

INTRODUCTION

Wheat flour has long been the cornerstone of traditional Egyptian balady bread production, valued for its unique gluten network that provides desirable texture and structure (El-Sohaimy .2019). However, growing nutritional awareness and economic pressures have spurred interest in partial wheat flour substitution with alternative ingredients, particularly nutrient-dense sweet potato (Ipomoea batatas) flour (SPF) (Bovell-Benjamin, 2020). This approach aligns with global trends toward sustainable food systems and enhanced nutritional profiles in staple foods (FAO, 2021).

Sweet potato flour offers compelling advantages as a wheat flour supplement, containing 15-30% more dietary fiber, higher levels of β-carotene (provitamin A), and antioxidant phenolic compounds compared to standard wheat flour (72% extraction) (Zhu et al., 2020). Recent studies demonstrate that SPF incorporation up to 20% can enhance the micronutrient content of baked goods without compromising basic functionality (Alamu et al., 2021). However, the high fiber (12.62%) and starch composition of SPF fundamentally alters dough rheology through gluten dilution and starch-gluten interactions (Maniglia et al., 2021).

The technological challenge lies in SPF's complete lack of gluten-forming proteins, which disrupts the viscoelastic matrix essential for bread quality (Rosell, 2021)..This is particularly critical for balady bread, where consumer expectations for specific sensory attributes (thin crust, open crumb structure) demand precise control of dough rheology (Kaur et al., 2023).

Recent advances in dough characterization techniques, particularly Farinograph and Extensograph analyses, provide quantitative insights into how non-wheat flours modify fundamental dough properties (Mancebo et al., 2021). These tools are essential for determining the maximum SPF incorporation level before significant quality deterioration occurs, as demonstrated in studies with similar root crop flours (Olatunde et al., 2021).

This study aims to evaluate the impact of partial substitution of wheat flour (72% extraction) with sweet potato flour (10–40%) on the rheological, nutritional, and sensory properties of Egyptian balady bread. Specifically, it seeks to determine the optimal substitution level that enhances nutritional value (e.g., protein, fiber, carotenoids) while maintaining acceptable dough functionality and sensory quality."

MATERIALS AND METHODS

Materials:

The Sweet potato *(Ipomea batata*) tuber, wheat *(Triticum aestivum*) flour, granulated sugar, were purchased from local market in Giza Egypt.

Methods:

Preparation of sweet potato flour:

Sweet potato (Ipomoea batatas) was thoroughly washed to remove dirt and soil. They were peeled, washed, blanched with 0.25% of sodium meta-bisulphate solution for 15 min, cut into slices and dried in a Gallenkamp hotbox oven at 70ºC for 18 hours. Dried sweet potato chips were milled into flour **(Eke and Kabari, 2010).** Flour obtained was sieved through a 60 mm mesh sieve to obtain flour of uniform particle size. The flour was then packed in an airtight container for future use.

Preparation of the balady bread:

Wheat flour 72% extraction was substituted with sweet potato flour at level 10, 20, 30 and 40%, respectively, to give four balady bread. These balady bread were kept at -20 ºC until analyses. To prepare the bread, 90 g of water, 40 g of white sugar (COFCO, China), 0.5 g of salt (China National Salt Industry Corporation), 200 g of mixed flour, and 3 g of yeast (Angel Yeast Co., Ltd) were put into a bread maker (MM-ESC1510, Midea). The WF (high gluten, COFCO) was replaced at ratios of, 10%, 20%, 30%, and 40%, respectively with sweet potato flour to make the bread.(Zhu et al.,٢٠٢٢)

Proximate of chemical composition of sweet potato flour and balady bread:

Protein, total lipids, crude fiber, ash content and total carbohydrates were determined in sweet potato flour and balady bread using standard methods **AOAC. (2005).** Total dietary fiber was determined of the dried raw materials according to the methods described by Lee **and Prosky (1995).** Also, soluble and insoluble dietary fiber determined according the method by Lee **and Prosky (1995).**

Determination of Carotenoids

Carotenoids were isolated and quantified in the Acquity UPLC system (Waters, Milford, MA, USA) samples by saponification (**Przybylska-Balcerek et al.,**

2019) at Agricultural Research Center (ARC). Carotenoid extracts in the amount of 0.4 mg were obtained from 10 g specimens of ground samples that were tittered with a mixture of acetone and petroleum ether (1:1). Plant tissue was separated, and acetone and hydrophilic fractions were removed from the extract by washing with deionized water. The ether extract was obtained with a mixture of carotenoid pigments. The prepared extract was concentrated in a vacuum evaporator at 35 °C until an oily residue was obtained. The residue was dissolved in 2 mL of methanol (Merck) and subjected to chromatographic analysis. Lutein, ZEA, and β-C were determined in the Acquity UPLC system (Waters, USA) with a Waters Acquity PDA detector (Waters, USA). Chromatographic separation was performed on an Acquity UPLC® BEH C18 column (100 mm × 2.1 mm, particle size 1.7 μm) (Waters, Ireland). Elution was carried out with A - MeOH solvent, B-water, and tert-butyl methyl ether (TBME). The elution gradient was applied at a flow rate of 0.4 mL min^{-1}. The column and the samples were thermostatted, with the column temperature at 30 °C, and the test temperature was 10 °C. During the analysis, the solutions were degassed in a Waters device. The injection volume was 10 μL. The separated compounds were registered at a wavelength λ = 445 nm. Compounds were identified based on spectra in the range of 200 to 600 nm, and retention times were compared with the standards.

Rheological properties of dough:

Farinograph tests:

Farinograph measurements on the wheat flour (14% moisture) blends with different ratio of date seed and pomegranate peel powders (5%, 10% and 15%) were determined by (A.A.C.C., 2002) at **Food Technology Research Institute (FTRI) – Agricultural Research Center (ARC)**

using a Brabender Farinograph (using the 100 g bowl, optimum water absorption (500 Bra- bender Units). Measurements obtained from the farinograph torque curve were flour water absorption (A), dough development time (B), dough stability (CD) and degree of softening (Flour water absorption, dough development time (DDT), arrival time, dough stability and degree of softening were determined using a farinograph and drop off consistency after 12 min (E12) were measured.

Extensograph tests

Rheological properties of dough were also tested using an Extensograph Brabender according to (A.A.C.C., 2002) at **Food Technology Research Institute (FTRI) – Agricultural Research Center (ARC)** as follows; wheat flour (300 g), sodium chloride (6 g) and optimum amount of water calculated from the water absorption were mixed for 8 min in Farinograph. Then the dough divided into 3 pieces (150 g/ piece) and kept in a humidity chamber at 30 ºC. After 45, 90 and 135 min of proofing, the doughs were stretched until they broke. The results were recorded on the extensogram as follows dough elasticity (E), dough resistance to extension (R), proportional number (R/E) and dough energy.

Wet, dry gluten and Gluten Index

Wet and dry gluten and Gluten Index of wheat flour were determined using (Glutomatic perten instruments AB type 2200 No. 005092. Huddling, Sweden) as described by AACC (2000) as follows: 10 g of flour sample put into glutomatic wash chamber equipped with a 88 micron polyester sieve; 4.8 ml of salt solution (2%sodium chloride) was added to the flour and mixed to from a dough during 20 seconds, the washing automatically start and continuous for 2 min. After that wet gluten transferred to another chamber equipped with the course 840-micron polyamide sieve, then the washing automatically restarts and continuous for 3 min. After that wet gluten transferred to special cassette and centrifuge for 1 min., at 6000 rpm. The fraction passed through the cassette weighed, while the fraction remained on the other side of the cassette collected and added to the balance, the total wet gluten obtained, then put in Glutork (type 22٠0) at 150℃ for 4 min., the obtained fraction calculated as dry gluten.

$$\text{Wet gluten content (\%)} = \frac{\text{Weight of wet gluten} \times 100}{\text{Weight of sample}}$$

$$\text{Dry gluten content (\%)} = \frac{\text{Weight of dry gluten} \times 100}{\text{Weight of sample}}$$

$$\text{Gluten index (\%)} = \frac{\text{Remained gluten on cassette (g)} \times 100}{\text{Total gluten}}$$

Sensory evaluation:

Balady bread organoleptically evaluated for their external and internal properties by ten stuff members of Food Technology research institute, agricultural research center. A maximum number of points were assigned to each bread characteristic identified as follows**,** Shape (10), Crust color (10), Crumb color (10), Crust appearance (10), Texture (10), Grain cell structure (20), Taste (20), Odor (20) and Overall acceptability (100) (**A.A.C.C., 2002).**

Statistical analysis

Statistical analyses were carried out by SPSS 19 program. Data were expressed as means ± SEM and the Statistical analysis was performed using one-way analysis of variance followed by Duncan's tests as according to **(Snedecor and Cochran, 1989).**

RESULTS AND DISCUSSION

Chemical analysis of sweet potato flour and its blends:

Chemical constituents and total dietary fiber fractions were determined in sweet potato flour and its blend and also, total phenolic and flavonoids compounds in ethanol extract were determined in sweet potato flour and its blend, results are reported in Table (1). The results showed that sweet potato flour had the highest protein content (15.71%), and the blends were gradually raised by increasing sweet potato flour from 10% (16.26%) to 40% (19.24%). The rise in protein in the blends could be attributed to sweet potato's higher protein content, whereas wheat flour's 72% extraction had the greatest protein content (11.90%). Sweet potato flour had a larger crude fiber and total dietary fiber content (12.62 and 41.11%, respectively) than ash and lipids (7.01 and 5.04%). Whereas the sweet potato blends were increased in chemical composition and total dietary fiber fractions by increasing sweet potato flour.

Dietary fiber in these preparations is important due to its functional effects in the gut. For instance, viscous fiber-containing foods may elicit low postprandial glycemic responses due to delayed glucose absorption **(Tovar *et al.*, 1992).**

Table (1): Chemical analysis of raw materials and its balady breads on dry weight basis

Chemical analysis (%)	Sweet potato flour	Wheat flour 72%	Blends with sweet potato flour at level			
			10 %	20%	30 %	40 %
Protein	15.71	11.90	16.26	17.52	17.91	19.24
Crude fiber	12.62	0.95	3.65	4.84	5.07	6.24
Ash	7.01	0.52	2.13	2.85	3.56	4.12
Lipids	5.04	2.38	2.87	3.34	3.91	4.32
TC	59.62	84.25	75.09	71.45	69.55	66.08
TDF	41.11	nd	4.35	8.14	12.85	16.43
TSDF	14.10	nd	1.54	2.27	3.21	4.51
TISDF	27.01	nd	2.81	5.87	9.64	11.92

TC: Total carbohydrates; TDF: Total dietary fiber; TSDF: Total soluble dietary fiber; TISDF: Total insoluble dietary fiber; nd: not detected

Carotenoid concentrations in the raw materials

Sweet potato flour, particularly from orange-fleshed varieties (OFSP), is rich in total carotenoids (TC), primarily β-carotene, which offers numerous health benefits, Carotenoids neutralize free radicals, reducing oxidative stress and inflammation linked to cancer, diabetes, and heart disease (Trancoso et al. 2020) . total carotenoids (mainly β-carotene) converts to retinol (vitamin A) in the body, preventing night blindness, immune dysfunction, and child mortality (Sanful et al. 2021).

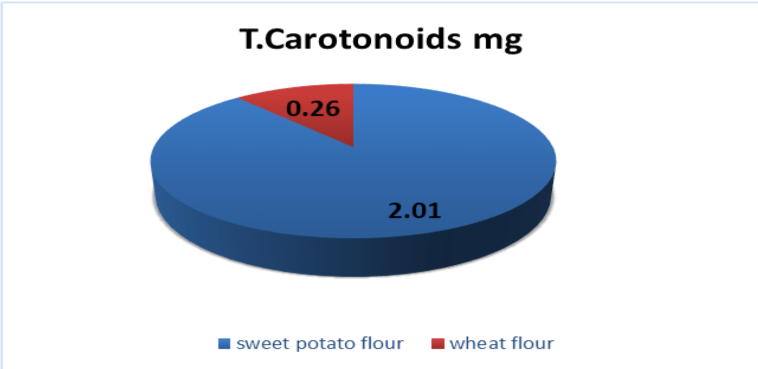


Fig. (1): Carotenoid concentrations in the raw materials

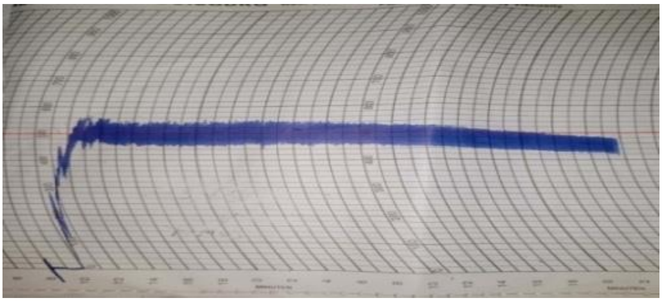
Effect of sweet potato flour on Farinograph properties of wheat flour (WF) blends dough:

Table 2 and Fig2 show the **rheological properties** of wheat flour (WF) blended with sweet potato flour (SPF) at varying substitution levels (10–40%) using farinograph analysis. Results represent that100% (WF) (Control) had the highest level of water absorption (59.5) compared to (90% (WF) + 10% SPF), (80% (WF) + 20% SPF), (70% (WF) + 30% SPF) and (60% (WF) + 40% SPF), (59 , 57,5,57 and58) respectively . The marginal reduction in water absorption with SPF addition indicates that SPF has lower water-binding capacity compared to WF, likely due to **reduced gluten content** and differences in starch structure **(Adeleke & Odedeji, 2010).** On the other hand it was shown that (90% (WF) + 10% SPF) produced the closest result in water absorption (59) when compared to 100% (WF) (Control) (59.5).In the same table results represent that arrival time of 100% (WF) (Control)was (1.5) while the (90% (WF) + 10% SPF),(80% (WF) + 20% SPF), (70% (WF) + 30% SPF) and(60% (WF) + 40% SPF), (1.00.1.5,1.5 and 1,5) respectively. The consistent arrival time indicates that SPF does not drastically alter the initial hydration rate of WF. This aligns with studies indicating that non-gluten flours minimally affect dough development time unless they disrupt gluten network formation **(Maniglia et al., 2021).**

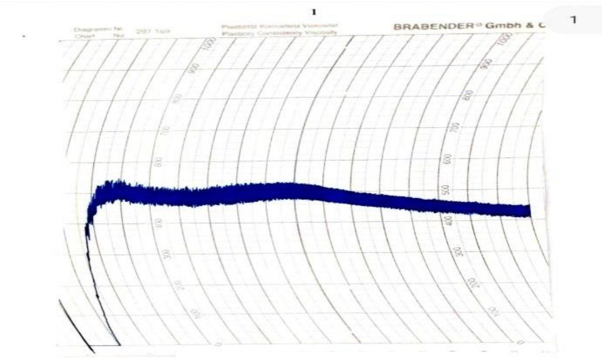
In the same table results represent that stability time of 100% (WF) (Control) (12) caused the highest level compared to (90% (WF) + 10% SPF), (80% (WF) + 20% SPF), (70% (WF) + 30% SPF) and (60% (WF) + 40% SPF) (8.5 ,8,8.5 and 3)) respectively. The **decreased stability** reflects gluten dilution. Gluten is critical for dough elasticity and mixing tolerance; its replacement with SPF weakens the network, leading to faster breakdown **(Rosell et al., 2011).**On the other hand Dough weakening(of (70% (WF) + 30% SPF) (60) was the highest value cumbered to 100% (WF) (Control) , (90% (WF) + 10% SPF),(80% (WF) + 20% SPF) and (60% (WF) + 40% SPF),(60 .60 .90 and 120) respectively. The longer weakening time at 30% SPF indicates a delayed but permanent gluten breakdown. SPF may initially stabilize the dough, but eventually promotes collapse due to the lack of cohesive gluten. On the other hand degree of softening (70% (WF) + 30% SPF) (110) caused the highest value compared to 100% (WF) (Control), (90% (WF) + 10% SPF), (80% (WF) + 20% SPF) and (60% (WF) + 40% SPF), (40,70,70,70) respectively. Increased softening suggests a low dough resistance to mechanical stress. SPF's high fiber content breaks gluten continuity and reduces dough strength. SPF alters WF's rheology by diluting gluten and modifying starch behavior. Blends ≤20% SPF may retain acceptable dough properties, but higher substitutions require technological interventions.

Table (2): Farinogram parameters of WF (72% Extraction) with different levels of sweet potato flour (SPF)

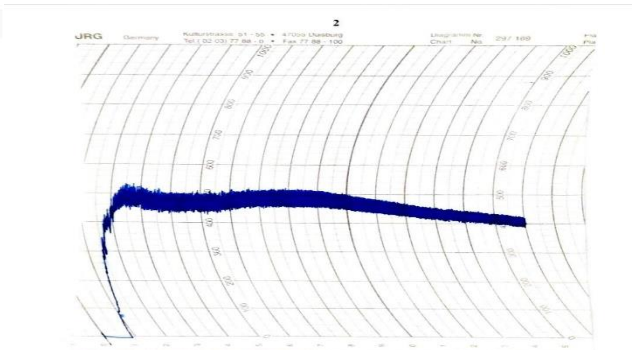
Samples	Water Absorption (%)	Arrival Time (min)	Stability Time (min)	Dough weakening(min)	Degree of softening (B U)
100% (WF) (Control)	59.5	1.5	1٤.0	60	40
90% (WF) + 10% SPF	59	1.00	8.5	60	70
80% (WF) + 20% SPF	57.5	1.5	8	90	70
70% (WF) + 30% SPF	57	1.5	8.5	120	110
60% (WF) + 40% SPF	58	1.5	3	90	70



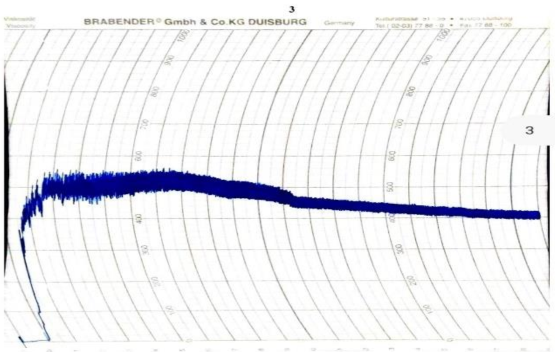
100% (WF)



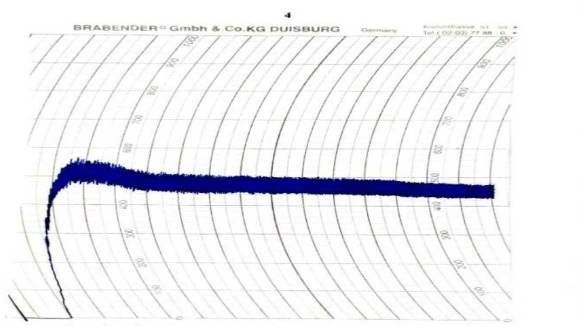
٩0% (WF)+ 10% SPF



٨0% (WF)+ 20% SPF



70% (WF)+ 30%



60% (WF)+ 40% SPF

Fig (2): Effect of substitution ratio of sweet potato flour (SPF) on farinograms of dough.

Table 3 and Fig 3 represent that the control sample (100% WF) showed excellent extensibility (170mm), characteristic of good gluten development. With SPF addition, extensibility decreased progressively, reaching a minimum (63mm) at 30% substitution. This 63% reduction indicates that Gluten network disruption due to SPF's lack of gluten-forming proteins **(Maniglia et al., 2021),** Interference of SPF starch granules with gluten matrix formation **(Olatunde et al., 2020).** On the other hand, Resistance values increased dramatically with SPF addition, peaking at 834BU (30% SPF) compared to 280BU for control. This suggests increased dough stiffness due to SPF fiber content **(Kaur et al., 2022**). While 90% (WF) + 10% SPF(280BU) showed the closest result compared to 100% (WF) (Control) (496BU On the other hand It was also, noticed that proportional number of (70% (WF) + 30% SPF) (14.7) caused the heist level cumbered to 100% (WF) (Control) (1.65), (90% (WF) + 10% SPF) (4.6), 80% (WF) + 20% SPF (9.8) and 60% (WF) + 40% SPF (4.0). This indicates Development of a stiff, non-extensible dough structure (Rosell et al., 2011). Energy values initially increased (peaking at 119cm² for 20% SPF) before decreasing at higher substitutions. This pattern suggests initial reinforcement by SPF components at lower levels, Subsequent network breakdown at higher substitutions **(Alamu et al., 2021)**. The increased softening values (up to 110BU at 30% SPF) confirm reduced dough stability under mechanical stress

Table (3): Extensograph parameters of WF (72% Extraction) with different levels of sweet potato flour (SPF)

Samples	Extensibility (ml)	Elasticity (BU)	Proportional Number	Energy (cm2)	Degree of softening (B
100% (WF) (Control)	170	280	1.65	70.9	40
90% (WF) + 10% SPF	106	496	4.6	112	70
80% (WF) + 20% SPF	96	675	9.8	115	70
70% (WF) + 30% SPF	63	834	14.7	85	110
60% (WF) + 40% SPF	150	603	4.0	119	70

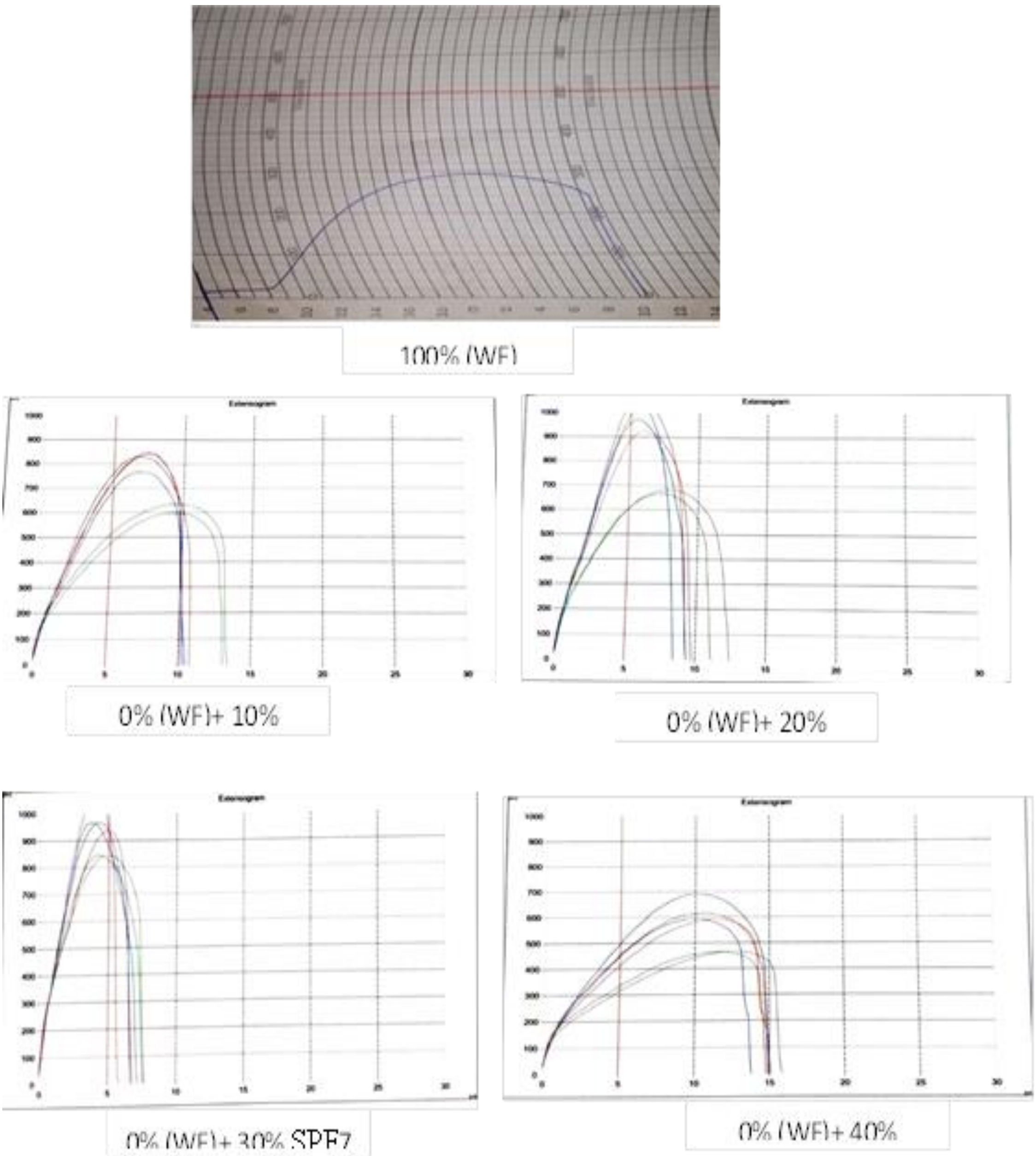


Fig (3): Effect of substitution ratio of sweet potato flour (SPF) on extensograph of dough.

From the results in Table٤ , it could be noticed that the100% (WF) (Control) caused the highest value of Wet gluten (32.58 ± 0.34) compared to (90% (WF) + 10% SPF),(80% (WF) + 20% SPF,70% (WF) + 30% SPF and 60% (WF) + 40% SPF) (24.9 ± 0.35[c], 26.8± 0.15[d], 21.5 ± 0.35[b] and 14.5± 0.36[a]) respectively. SPF Blends Significant reduction ($p<0.05$) from 24.9g (10% SPF) to 14.5g (40% SPF). SPF lacks gluten proteins (gliadin and glutenin), directly reducing gluten content **(Alamu et al., 2021).** 40% SPF showed 55.5% gluten reduction, consistent with **Maniglia et al. (2021).** In the same table results represent that the100% (WF) (Control) caused the heist percent of Gluten index% (85.46) cumbered to (90% (WF) + 10% SPF),(80% (WF) + 20% SPF)and (70% (WF) + 30% SPF) (83.47,82.47,81.83and 80.6) respectively. High gluten index (>80%) maintained despite substitutions indicates SPF components don't severely disrupt gluten polymerization **(Rosell et al., 2011).** Wheat gluten remains functionally dominant **(Olatunde et al., 2020).**

Table (4): Wet gluten and gluten index of WF (72% extraction) with different Levels of sweet potato flour (SPF)

Treatments	Wet gluten (g)	Gluten index (%)
100% (WF) (Control)	32.58 ± 0.34[e]	85.46
90% (WF) + 10% SPF	24.9 ± 0.35[c]	83.47
80% (WF) + 20% SPF	26.8± 0.15[d]	82.47
70% (WF) + 30% SPF	21.5 ± 0.35[b]	81.83
60% (WF) + 40% SPF	14.5± 0.36[a]	80.6

Means with different letters among treatments in the same column are significantly different ($p\leq0.05$). Data are presented as means ± SD(n=3).

Sensory evaluation

Sensory evaluation of wheat flour (WF) balady bread fortified with sweet potato flour (SPF)

This complete sensory study examines the effect of SPF incorporation (10-40%) on the quality attributes of traditional Egyptian balady bread. The data show significant changes in all sensory metrics as SPF levels increase. From the results in Table 5, it could be noticed that 100% (WF) (Control) caused the highest scores of shape (9.0[a]± 0.5)) compared to (90% (WF) + 10% SPF),(80% (WF) + 20% SPF),(70% (WF) + 30% SPF and 60% (WF) + 40% SPF) (8.70[b]± 0.1, 8.0[c]± 0.15, 6.95[d]± 0.15and 5.75[e]± 0.05) respectively. In the same table results represent that (60% (WF) + 40% SPF) caused the lowest scores (5.75[e]± 0.05), Gluten dilution reduces dough elasticity, affecting shaping ability (**Alamu et al., 2021).** On the other hand, the100% (WF) (Control) scored (9.2[a]± 0.16) (golden-brown, uniform) Crust appearance. while 40% SPF dropped to (5.5[e]± 0.1) (paler, less attractive), This signifies a reduced protein content. (**Zhu et al., 2019**). In the same table, data show that (90% (WF) + 10% SPF) and (80% (WF) + 20% SPF) resulted in the closest scores (8.7b± 0.12, 8.25c± 0.11) to 100% (WF) (Control) (9.2a± 0.16).On the other hand (100 % WF .control)) caused the highest scores of crust color (9.25[a]± 0.15)) compared to(90% (WF) + 10% SPF),(80% (WF) + 20% SPF),(70% (WF) + 30% SPF and60% (WF) + 40% SPF) ,(8.75[b]± 0.15, 8.35[c]± 0.12 , 7.05[d]± 0.2 and 5.35[e]± 0.05) respectively. SPF's natural pigments create yellowish hue (**Maniglia et al., 2021)**. In the same table, data show that (90% (WF) + 10% SPF) and (80% (WF) + 20% SPF) resulted in the closest scores (8.75[b]± 0.15and 8.35[c]± 0.12) to 100% (WF) (Control) (9.25[a]± 0.15). In the same table results represent that(90% (WF) + 10% SPF) and (80% (WF) + 20% SPF) resulted in the closest scores of crumb color (8.85[b]± 0.25, 8.25c± 0.18.40[c]± 0.051) to 100% (WF) (Control) (9.25[a]± 0.15).While 60% (WF) + 40% SPF caused the lowest scores (5.50[e]± 0.14) cumbered to100% (WF) (Control), (90% (WF) + 10% SPF),(80% (WF) + 20% SPF),(70% (WF) + 30% SPF). SPF's natural pigments create yellowish hue **(Maniglia et al., 2021**).

In the same table results represent that (60% (WF) + 40% SPF) caused the lowest scores (5.20[e]± 0.14) of crumb texture cumbered to (100% (WF) (Control), (90% (WF) + 10% SPF),(80% (WF) + 20% SPF),(70% (WF) + 30% SPF) (9.35[a]± 0.5, 8.65[b]± 0.15, 8.20[c]± 0.35 and 6.65[d]± 0.05) respectively. This due to Fiber interference creates coarser texture (**Kaur et al., 2022**). In the same table, data show that Grain cell structure of 100 % WF (.control)) caused the highest scores (9.25[a]± 0.2) cumbered to (90% (WF) + 10% SPF),(80% (WF) + 20% SPF),(70% (WF) + 30% SPF and60% (WF) + 40% SPF) .On the other hand (60% (WF) + 40% SPF)) caused the lowest scores (5.40[e]± 0.11

compared to (100 % WF. Control ,90% (WF) + 10% SPF), (80% (WF) + 20% SPF and 70% (WF) + 30% SPF). this due to Weakened gluten fails to retain gas effectively **(Rosell et al., 2011**). In the same table, data show that (90% (WF) + 10% SPF) and (80% (WF) + 20% SPF) resulted in the closest scores of Grain cell structure (8.80^{b}± 0.1, 8.35^{c}± 0.12) to 100% (WF) (Control) (9.25^{a}± 0.2). On the other hand In the same table results represent that (90% (WF) + 10% SPF) closest scores of Taste (18.30^{a}± 0.17) to100% (WF) (Control) (18.45^{a}± 0.3) follow by (80% (WF) + 20% SPF) (17.90^{b}±0.22).In the same table data show that (60% (WF) + 40% SPF)) caused the lowest scores of Odor (14.00^{d}± 0.1) compared to (100 % WF. Control, 90% (WF) + 10% SPF), (80% (WF) + 20% SPF and 70% (WF) + 30% SPF). Overall acceptability of (90% (WF) + 10% SPF and 80% (WF) + 20% SPF) (88.80^{b}± 0.1, 85.65^{c}± 0.03) closest scores to100 % WF (control) (92.10a± 0.3). While 10-20% SPF substitution produces sensorial acceptable balady bread, higher substitutions require technological interventions to maintain traditional quality attributes.

Table (5): Sensory evaluation of balady bread prepared from WF (72% extraction) and different sweet potato flour (SPF)

Treatments	**Shape 10**	**Crust Appearance 10**	**Crust color 10**	**Crumb color 10**	**Crumb texture 10**	**Grain cell structure 10**	**Taste 20**	**Odor 20**	**Overall 100**
100 % WF.	9.0^{a}± 0.5	9.2^{a}± 0.16	9.25^{a}± 0.15	9.25^{a}± 0.15	9.35^{a}± 0.5	9.25^{a}± 0.2	18.45^{a}± 0.3	18.35^{a}± 0.2	92.10^{a}± 0.3
90% (WF) + 10% SPF	8.70^{b}± 0.1	8.7^{b}± 0.12	8.75^{b}± 0.15	8.85^{b}± 0.25	8.65^{b}± 0.15	8.80^{b}± 0.1	18.30^{a}± 0.17	18.05^{ab}	88.80^{b}± 0.1
80% (WF) + 20% SPF	8.0^{c}± 0.15	8.25^{c}± 0.11	8.35^{c}± 0.12	8.40^{c}± 0.05	8.20^{c}± 0.35	8.35^{c}± 0.12	17.90^{b}± 0.22	18.20^{a}± 0.35	85.65^{c}± 0.03
70% (WF) + 30% SPF	6.95^{d}± 0.15	7.15^{d}± 0.1	7.05^{d}± 0.2	6.90^{d}± 0.15	6.65^{d}± 0.05	6.85^{d}± 0.11	15.35^{c}± 0.1	15.35^{c}± 0.05	72.25^{d}± 0.2
60% (WF) + 40% SPF	5.75^{e}± 0.05	5.5^{e}± 0.1	5.35^{e}± 0.05	5.50^{e}± 0.14	5.20^{e}± 0.14	5.40^{e}± 0.11	13.95^{d}± 0.4	14.00^{d}± 0.1	60.65^{e}± 0.15

Means with different letters among treatments in the same column are significantly different ($p \leq 0.05$). Data are presented as means ± SDM (n=3).

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الملخص العربي

اثر استبدال دقيق البطاطا الحلوة على الخواص الريولو جية والتكنو لوجية للخبز البلدى

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بحثت هذة الدراسة فى اثار استبدال دقيق القمح (استخراج ٧٢٪) بدقيق البطاطا الحلوة (١٠ – ٤٠٪) على الخصائص الريولوجية والتغذوية والحسية للخبز البلدى المصرى. كشفت تحليلات فارينو جراف واكستنفو جراف ان اضافة دقيق البطاطا الحلوة قللت تدريجيا من امتصاص الماء(٥٩,٥٪ الى٥٧٪) واسقرار العجين(١٤ الى ٣ دقائق), وقابلية للتمدد(١٧٠ الى ٦٣مم), مع زيادة ومقاومة التمدد(٢٨٠ الى ٨٣٤ وحدة قياس) مما يشير الى خلل فى شبكة الجلوتين. انخفض محتوى الجلوتين الرطب بشكل ملحوظ(٣٢,٥٨ الى ١٤,٥ جم) على الرغم من ان مؤشر الجلوتين ظل اعلى من٨٠٪ فى جميع مستويات الاستبدال. من الناحية الغذائية زاد دقيق البطاطا الحلوة من البروتين(١٥,٧١ الى ١٩,٢٤٪) والالياف الغذائية (٤١,١١٪) ومحتوى الكاروتينات بالمقارنة بالمجموعة الضابطة. اظهر التقييم الحسى ان مخاليط ١٠٪و٢٠٪ من دقيق البطاطا الحلوة حافظت على قبولها(٨٨,٨٠/١٠٠مقابل ٩٢,١٠ للمجموعة الضابطة) بينما سجلت البدائل الاعلى(٣٠ – ٤٠ %) نتائج ضعيفة فى الملمس ولون القشرة والجودة العامة. خلصت الدراسة الى ان استبدال دقيق البيطاطا الحلوة بنسبة ١٠ الى ٢٠٪ يحسن القيمة الغذائية بشكل مثالى دون المساس بجودة الخبز بينما تتطلب المستويات الاعلى تدخلات تكنولوجية للتخفيف من التدهور الريولوجى.

الكلمات المفتاحية
دقيق البطاطا الحلوة, خبز بلدى, مؤشر الجلوتين, فارينو جراف, التقييم الحسى.