PAPER

PHYSICOCHEMICAL, RHEOLOGICAL, AND SENSORY EVALUATION OF VOLUMINOUS BREADS ENRICHED BY *PURSLANE* (*PORTULACA OLERACEA L.*)

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ABSTRACT

Portulaca oleracea (purslane) can be used as a vegetable and herb for medical and food products. The aim of this study was to investigate the psychochemical, rheological, and sensory properties of voluminous breads enriched by different amounts of *purslane* powder (0, 5, 10, and 15%) were compared to a control group. The results showed that, with an increase in the concentration of *Purslane* in samples, water absorption capacity, stability under mixer, and softening level increased. Adding 15% of *purslane* powder decreased farinograph quality number significantly. Addition of *purslane* powder also improved resistance to extension and decreased extendibility, energy, and viscosity of the dough significantly. In terms of sensory properties, the sample with 15% *purslane* powder obtained the minimum score and other samples had acceptable conditions in terms of different sensory properties like taste, texture, color, odor, and general acceptability. In summary incorporation of *purslane* in voluminous bread is feasible and the optimum percentage of the purslane powder is 10% for the best acceptance in sensory evaluation.

Keywords: bread, *Portulaca oleracea*, *Purslane*, sensory evaluation, fortification, physichochemical properties

1. INTRODUCTION

Wheat products like flour and bread are good carries for adding nutrients needed by the consumers (EL KHOURY *et al*., 2018). In addition, bread is the staple food of about one half of the world population and a reliable source in terms of nutrition and inexpensive diet (GRAHAM, Welch, and Bouis, 2001). To improve nutritional support for low income families, it is essential to pay more attention to improving quality and diversity of available breads, minimize the wastes, and produce breads with strong sensory properties (GUYOT, 2012). Along with being a main source of energy, bread also supplies the dietary fibers, some minerals (iron (Fe), calcium (Ca), and vitamin B group and vitamin E (found in wheatgrass) (KAUR, 2011). Improvement of texture, volume, crust, and quality of bread is one of the advantages of using fat in bread formulation (EL-SOHAIMY *et al*., 2019). Another role that is filled is adding tastes and energy content of the product. As shown by the literature, fat tastes in breads are more desirable for the consumer than other tastes (HEENAN *et al*., 2008).

Portulaca oleracea (purslane) is a grassy annual plant in the family Oleracea with succulent stems, yellow or white small flowers, black seeds, and medicinal properties. The wild plant is a watery weed that prefers warm and arid condition and grows in a wide range of soils and climates. According to the traditional medicine, the plant has a cold and moist humor, styptic, and diuretic and decreases bile sack movement and bile flow in return (ASADI GHARNEH and REZA HASSANDOKHT, 2008; NAEEM and KHAN, 2013). *Purslane* is a well-known plant in traditional medicine with protective effect on the liver that is used for several therapeutic purposes. It preserves the liver against the damages caused by free radical invasion and lipid peroxidation in the endoplasmic grid of cells (ZAREI *et al*., 2015) (HADI *et al*., 2018). In addition, *purslane* is rich of antioxidant compounds and a good source for flavonoid, and carotenoid (M. ALAM *et al*., 2014). In addition, there has been no report of toxic effects of this plant. In addition to the said effects, *purslane* demonstrated anti-pain and anti-inflammatory effects. It is the richest plant source of W-3 (M. ALAM *et al*., 2014; UDDIN *et al*., 2014). Total fat content of the leaves range from 1.5 to 2.5 mg/g of fresh mass out of which around 60% and 40% is α-Linolenic acid (C18:3ω3) (LIU *et al*., 2000). Nowadays, researchers are looking for the ways to enrich food products, meet nutritional needs, and improve health in the consumers. So far, different additives have been added to bread formulation such as *purslane* seed flour (FATHNEJHAD KAZEMI *et al*., 2012), flaxseed flour (MERVAT *et al*., 2015), fenugreek flour (NASEHI *et al*., 2018), and garlic flour (BALESTRA *et al*., 2011). In addition, the importance of using medicinal plants in pharmaceutical and economic fields is quite clear (BHAT *et al*., 2013; DANESHZADEH *et al*., 2020; GUARIGUATA *et al*., 2014; WHITING *et al*., 2011).

Taking into account the high rate of linolenic fat acid in some of oil seeds like *purslane* seed, the high consumption rate of bread, and low consumption rate of essential fatty acids per capita, the present study is an attempt to survey the possibility of using *purslane* to enrich voluminous breads to improve physicochemical, rheological, and sensory qualities of the breads.

2. MATERIALS AND METHODS

2.1. *Purslane* powder preparation

Shahroud strand of *purslane* plant was collected from a vineyard in Shahroud, Semnan Province, Iran. The plats were washed with distilled water to remove dust, cleaned, and dried at room temperature (35±2°C) for several days till complete dryness and then powdered using a laboratory grinder (Pars Khazar, Rasht, Iran). The powder was sieved using a sieve with mesh size of 0.5 at most. The obtained powder was kept in a capped container in fridge (0-4°C).

2.2. Voluminous bread samples preparation

As the control group, voluminous bread formulation is listed in Table 1. To prepare the samples and according different levels of purslane powder to replace wheat flour (0 (control), 5, 10, and 15% w/w) was mixed with wheat flour, yeast suspension (2%) and other ingredients using an electrical mixer and incubated at 30°C for 30 minutes (Pars Khazar, Rasht, Iran).
Water content was determined using farinograph and the dough was mixed for 10min. To mix the dough, spiral mixer was used, and the dough was cut into 150 gr pieces. The baking process took 25-30 min at 180°C in an electrical convection oven (SM-705E Model, SINMAG, Jakarta, Indonesia). Afterwards, the breads were cooled down and packed in polyethylene packages for further examination (SHITTU *et al*., 2009).

Table 1. Voluminous bread formulation.

Ingredients	Amounts
Flour	1 kg
Sugar	10 g
Yeast	10 g
Vegetable oil	10 g
Salt	5 g
Water	Enough

2.3. Physicochemical and Rheological analysis

2.3.1 Analyzing wheat flour, purslane powder, and voluminous breads

Moisture, ash, total protein, fat, raw fiber, falling number, and moist gluten were determined according to AACC method (2000) under code numbers 44-15A, 08-01, 46-13, 30-10, 32-10, 81-56, 54-11, and 12-38, respectively (AACC, 2000).

2.3.2 Dough rheological analysis

To examine amylograph properties of dough samples, an amylograph device (Brabender, Germany) was used based on the standard instruction. Rheological properties of different samples were determined using farinograph and amylograph based on AACC method

(2000) No. 54-21 and 54-30. Then different parameters like water adsorption, dough development time (DDT), stability of dough, and mixture resistance index were plotted on farinograph diagrams and parameters like gelatinization and viscosity were extracted based on amylograph diagram (AACC, 2000).

2.3.3 Physicochemical analysis of voluminous bread

The bread samples were analyzed using AACC (2000). The moisture, raw protein content, fat content, ash content, and gluten content were determined through 44-15, 46-13, 30-25, 01-08, and 38-11 methods respectively (AACC, 2000).

2.4. Sensory evaluation

The quality of breads, fresh and cooled down in ambient temperature, was examined by 20 trained examiners (10 men and 10 women) were analyzed. Sensory specifications included tastes, texture, color, odor, and general acceptability. The samples were coded randomly and provided to the examiners in separate containers. They scored the samples based on a five-point scoring system (5= very good, 4 = good, 3= moderate, 2= bad, and 1= very bad) (GHANBARI and FARMANI, 2013; YASEEN *et al*., 2010).

2.5. Statistical analysis

All experiments were done with three replicates using ANOVA in SPSS 22 (Chicago, IL, USA). To compare mean score ($P<0.05$), Duncan's multiple range test was used. The independent variable was different levels of *purslane* powder and dependent variables were all the experiments on the treatments. Figures were developed in MS Excel.

3. RESULTS AND DISCUSSION

3.1. Physicochemical properties of wheat flour and purslane powder

Physicochemical properties of wheat flour and *purslane* are listed in Table 2. As listed, moisture of wheat flour is higher than that of *purslane* powder; while *purslane* powder has higher fat, protein, total ash, and fiber content compared to wheat. *Purslane* powder did not have gluten and alpha amylase activity.

3.2. Dough rheological analysis

3.2.1 Farinograph test on the dough

Results of water absorption (WA) in farinograph test (Table 3) showed that by adding *purslane* powder into the wheat flour, WA capacity decreases notably so that the control sample contained 57.96% water and the sample containing *purslane* powder (15%) only contained 55.1% water. Still, the decrease in WA rate in the samples with 5 and 10% of *purslane* powder was not significant ($p>0.05$). Since, *purslane* powder contains hydrophobe chemical compounds like fatty acids, the decrease in WA capacity by adding *purslane* powder is expectable.

As listed in Table 3, by increasing the level of *purslane* powder in dough sample, stability time in mixture decreases. Dough Stability (DS) time in the control sample was 4.98min and for the samples with 5, 10, and 15% *purslane* powder, this time was 4.63, 4.26, and 3.65 min respectively. The decrease in stability time by replacing wheat flower by *purslane* powder is rooted in dilution or degradation of gluten grid. Physical break of gluten grid can be a reason for the less stable dough as gluten proteins are responsible for viscoelastic grid and stability of dough and *purslane* powder does not contain gluten. (MACRITCHIE, 2010).

Table 2. Physico-chemical properties of wheat flour and *purslane* powder.

Parameters	Wheat flour	*Purslane* powder
Moisture (%)	13.83±0.59[a]	4.72±0.45[b]
Protein (%)	8.89±0.33[b]	16.39±0.24[a]
Fat (%)	1.49±0.14[b]	4.79±0.06[a]
Ash (%)	0.72±0.11[b]	18.12±0.08[a]
Crude fiber (%)	0.13±0.03[b]	4.78±0.05[a]
Wet gluten (%)	24.16±0.27	-
Felling number (Seconds)	**353**	-

*Different letters in the same row indicate significant differences (P<0.05).

The degree of loosening analysis showed that by adding high levels of *purslane* powder to the dough samples, looseness of the sample increased notably after 12 min (Table 3). This increase in looseness can be explained by the dilution of gluten proteins that weakens the dough. *Purslane* powder also contains unsolved fibers that weaken gluten functions. Dough weakening levels for the control and samples with 5, 10, and 15% *purslane* powder were 89.68, 91.29, 95.13, and 100.85 BU respectively.

Farinograph quality number (FQU) for different samples is listed in Table 3. Clearly, adding *purslane* powder to the dough sample (15%) caused a significant decrease in FQU ($p<0.05$) as adding the powder decreases stability of the dough. In general, there was no significant difference between FQU of the control and *purslane* samples 5% and 10% ($p>0.05$).

XU *et al*. (2014) showed that adding linseed flour to wheat flour increased WA, dough expansion time, and dough resistance (XU *et al*., 2014). GARDEN (1993) consistently found that mixing linseed and wheat flour decreased stability of dough significantly (Garden-ROBINSON, 1993).

KOCA and ANIL (2007) reported that the reason for the difference in the mixture of dough containing linseed was dilution of gluten protein by fiber and the reaction between fiber materials and gluten, which also affects the mixing process (KOCA and ANIL, 2007).

Farinograph results by KOCA *et al*. (2007) showed that by increasing linseed content, WA, dough expansion, and mixture resistant index increased; while DS decreased by adding different levels of linseed (KOCA and ANIL, 2007). These findings are consistent with the present study.

Table 3. Farinograph characteristics of dough samples.

Samples	Moisture absorption (%)	Dough stability time (min)	Degree of loosening (after 12 minutes fermentation) (B.U.)	Farinograph qualitative number
Control	57.96±0.42[a]	4.98±0.32[a]	89.68±2.42[c]	58.16±2.37[a]
5% of *purslane* powder	56.39±0.59[b]	4.63±0.19[ab]	91.29±2.01[bc]	57.89±1.14[a]
10% of *purslane* powder	55.61±0.32[bc]	4.26±0.29[b]	95.13±1.94 [b]	53.91±2.02[a]
15% of *purslane* powder	55.11±0.48[c]	3.65±0.24[c]	100.85±2.06[a]	47.96±1.68[b]
P-value	**0.000**	**0.000**	**0.000**	**0.013**

*Different letters in the same column indicate significant differences (P<0.05).

3.2.2 Extensograph test on dough

Rheology tests with large deformation range, including one-side extension test using an *extensograph* device yielded information about viscoelastic behavior of dough and dilatancy of gluten grid (GILBERT, 2002). Since, extensograph results have direct relationship with gluten protein properties, changes in dough resistance to extension and extendibility of dough can be attributed to the interactions between fiber structure and gluten protein.

The results of the effects of different concentration of *purslane* powder on extension strength of the dough (Fig. 1a) showed that with a longer rest time of 45-135 min, extension strength of the samples increased significantly both in the control and experiment groups (p<0.05). The dough rest was in extensograph container and during resting and due to changes in glutens, the ingredients were revived and a uniform gluten grid was reestablished due to the changes in gluten (XU *et al*., 2014). Therefore, extension strength after the rest time is improved. At different rest times (45, 90, and 135min), adding *purslane* powder increases tensile strength of dough due to high fiber content of the powder. In general, the highest level of tensile strength happened in the samples with 15% *purslane* content and fermentation time of 135min (247.75 BU) and the lowest level was with the control sample with fermentation time of 45min (169.77 BU).

Extendibility levels of different dough samples are demonstrated in Fig. 1b. Clearly, in the samples with different concentrations of *purslane*, extendibility is notably less than the control samples (p<0.05). This can be due to the larger size of *purslane* powder particles compared to wheat flour that causes early rapture of gluten under extension. The second cause might be dilution of dough protein so that changes the ratio protein to starch (MACRITCHIE, 2010), the increase in tensile strength and decrease in its extendibility with different concentration of *purslane* powder is justifiable. In short, with different fermentation times, the highest extendibility was observed with the control sample and the lowest level was observed with the control sample with fermentation time of 45 min (14.73 cm).

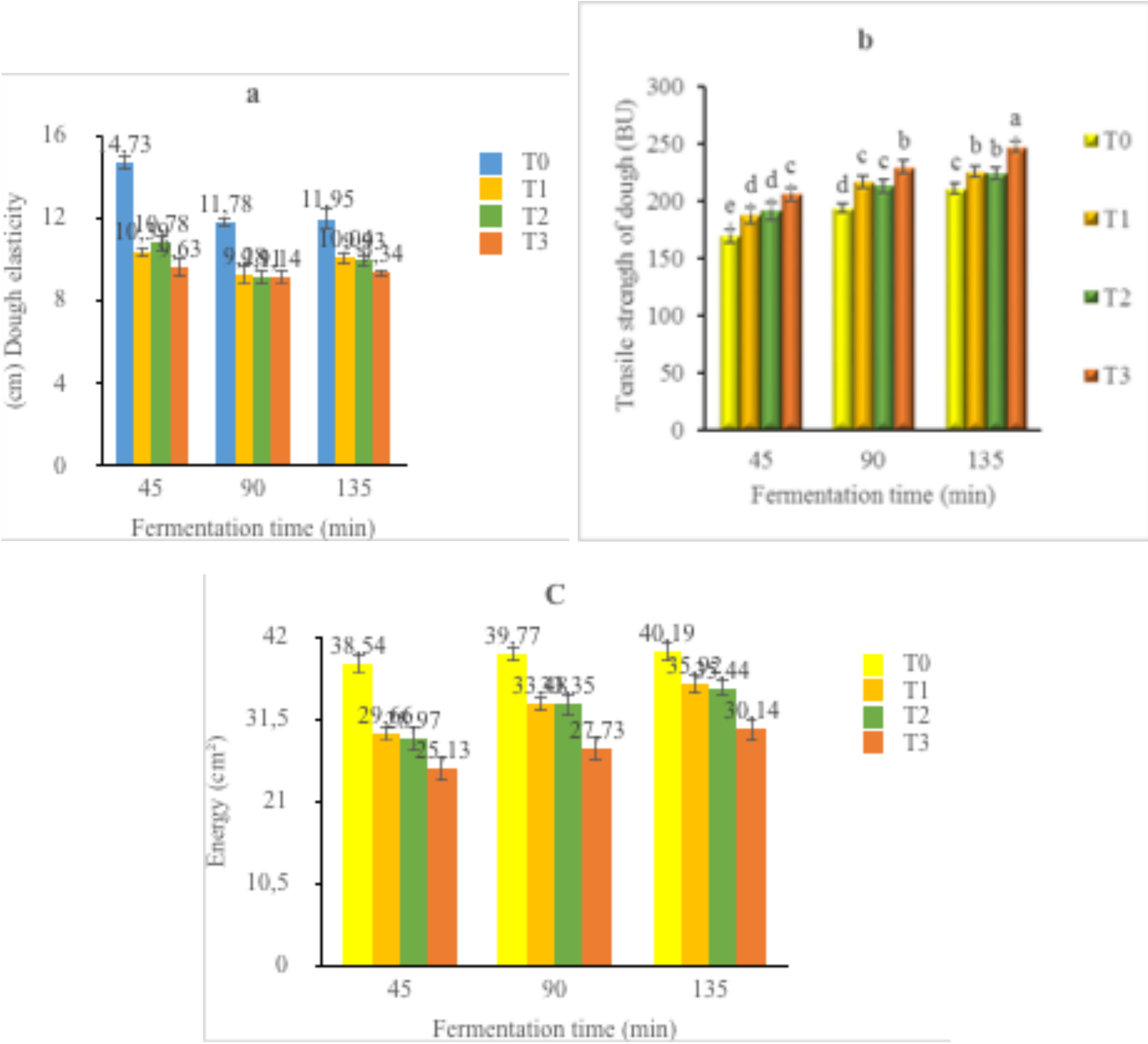

Figure 1. Comparison of mean values of (a) dough elasticity (cm), (b) tensile strength of dough (BU), (c) energy (cm2) of different dough samples during different fermentation times. Different letters on bars represent significant differences among means.

The area under diagram and dough energy indicates the energy or mechanical work needed for extending the dough until rapture. This is a reliable index of dough strength. For academic purposes, the curve height and the area under it are considered as strength index and the higher this index, the higher the strength of dough (GILBERT, 2002). The mean area under the diagram or tough energy of different dough samples containing different concentration of *purslane* powder with fermentation periods 45, 90, an d135min in extensograph is illustrated in Fig. 1c. The highest and lowest levels of dough energy with different fermentation time were obtained by the control and *purslane* powder (15%) respectively. There was no significant difference between the energy level of the samples with 5 and 10% of *purslane* powder regardless of fermentation time. Still, the increase in fermentation concentration time from 10 to 15% had a significant effect on the dough energy (considerable decrease). The sample with different levels of *purslane* powder

demonstrated a gradual increase in energy level of dough with an increase in fermentation time in the extensograph. MARIOTTI *et al*. (2006) reported rheological and baking performance specifications of bread with different levels of *Avena sativa* flour and showed that adding *Avena sativa* decreased WA and strength of breads (MARIOTTI *et al*., 2006).
STEPNIEWSKA *et al*. (2019) examined the quality of breads with rye flour and found that lower protein content, lower unsolved total pentosan content, higher solved pentosan content in water, flour granola, and solved content in water (pentosan in particular) had a significant effect on the hardiness of bread samples (STĘPNIEWSKA *et al*., 2019).
Marie and Ivan (2017), consistent with our findings, reported that replacing linseed fiber had a significant effect on the energy of extensogram curve (MARIE and IVAN, 2017).

3.2.3 Amylograph analysis

Table 4 lists the results about the effect of different levels of *purslane* powder on gelatinization of wheat flour-based dough. Clearly, despite the trivial increase in gelatinization temperature (GT) caused by the increase in the volume of *purslane* powder in the samples, there is no significant difference between the control and experiment samples in terms of GT (p>0.05).

Table 4. Amylograph results of dough samples.

Variables	Control	5%	10%	15%
Gelatinization temperature (°C)	58.37±0.08^{a}	58.39±0.09^{a}	58.46±0.05^{a}	58.51±0.08^{a}
Viscosity (BU)	1941.2±4.7^{a}	1929±5.4 ^{b}	1917.5±2.9^{c}	1906.2±4.1 ^{d}

*Different letters in the same column indicate significant differences (P<0.05).

Viscosity of the control and experiment samples is listed in Table 4. Clearly, the control sample has the highest viscosity (1941.2 BU) and adding *purslane* powder created a significant decrease in viscosity of the samples (p<0.05). That is, viscosity levels in the samples with 5, 10, and 15% of *purslane* powder were 1929.0, 1917.5, and 1906.2 BU respectively. The reason for this decrease in viscosity after adding *purslane* powder to the sample can be the decrease in gluten protein content. Therefore, with an increase in *purslane* concentration, the continuous grid of gluten is broken and viscosity declines (SALIM-UR-Rehman, 2006; YOUSIF *et al*., 2012).
SALIM-UR-REHMAN *et al*. (2006) showed that increasing the content of sorghum flour up to 30%, lowered the viscosity of dough (SALIM-UR-REHMAN, 2006). INDRANI *et al*. (2015) reported that adding ground black gram to dough sample increased viscosity of the dough samples notably. Their results are consistent with the results here (INDRANI *et al*., 2015). MLAKAR *et al*. (2009) showed that replacing amaranthus flour up to 10% did not have any effect on GT of wheat flour dough, while adding 20% amaranthus flour increased starch GT (MLAKAR *et al*., 2009). Moreover, a significant decrease in viscosity of the dough due to adding amaranthus flour was reported.

3.3. Bread samples analysis

3.3.1 Bread moisture content

Fig. 2a illustrates results of moisture assessment of the samples with different levels of *purslane*. Clearly, the lowest moisture level is with the control sample (33.53%) and the moisture increases significantly with the increase of *purslane* content to 5 and 10% ($p<0.05$). Still, the increase in *purslane* powder level from 10 to 15% decreases moisture content. The increase in moisture content with the lower levels of *purslane* can be explained by the high fiber content in *purslane*, which preserves moisture in the samples. Still, with further increase in *purslane* content, gluten grid is degraded and its capacity to store water decreases. The powder contains hydrophobic chemical compounds like fatty acids that decrease water content.

DEMINE *et al*. (2013) showed that adding quinoa flour to flour formulation creates a significant decrease in moisture content of bread samples (DEMIN *et al*., 2013). Still, the increase in quinoa flour did not have a significant effect on bread samples moisture. GOHAR *et al*. (2016) stated that replacing a part of wheat flour with quinoa flour decreased moisture content significantly (GEWEHR *et al*., 2016). As to the increase in moisture content after adding amaranthus flour to the formulations used by baking industries, INGLETT *et al*. (2015) studied cookies containing amaranthus flour. They showed that adding amaranthus flour increased moisture capacity in baking process comparing with other samples (INGLETT *et al*., 2015).

TEUTONIC and KNORR (1985) showed that amaranthus seeds have 3.54% lignin and this increases the capacity to store water (TEUTONICO and KNORR, 1985). In addition, ELGETI *et al*. (2014) used quinoa flour and replaced it with rice and corn flour up to 40-100% to obtain gluten free bread. The results showed that along with improving the volume of bread, quinoa flour created a softer inner texture, distributed air cell more evenly, had a positive effect on moisture content of the samples and delayed going stale (ELGETI *et al*., 2014). They argued that the increase in moisture content of the samples was due to adding fiber-rich flour (e.g. lignin) to the samples.

3.3.2 Breads protein content

Fig. 2b illustrates protein content of the samples. Clearly, the minimum protein content appears in the control sample (10.05%) and since *purslane* powder contains more protein than wheat flour, adding *purslane* powder to the formulation created a significant change on protein content ($p<0.05$) so that samples with 5%, 10%, and 15% *purslane* powder contained 11.82%, 12.48%, and 12.91% protein content respectively.

HOSSEIN and SALEM (2016) studied enrichment of gluten-free snacks using different levels of *purslane* and showed that adding *purslane* increased protein content of the products significantly (HUSSIEN and SALEM, 2016). ASMA and GINDY (2017) showed that adding *purslane* powder to bread samples increased protein content significantly (ASMA and GINDY, 2017). ALMASOUD and EMAN (2014) found that adding *purslane* significantly increased protein content of crackers (ALMASOUD and EMAN, 2014). These findings are consistent with our findings.

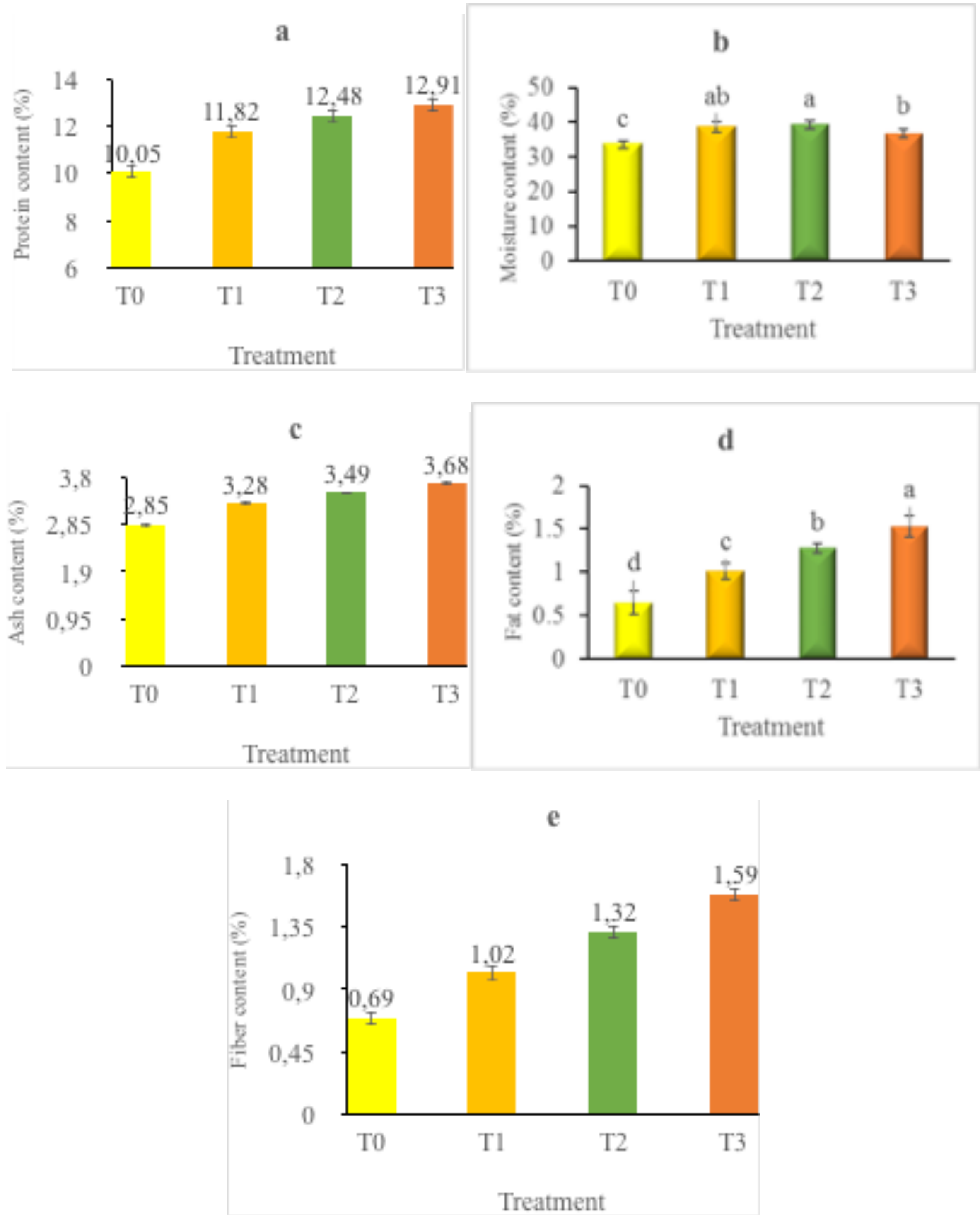

Figure 2. Comparison of (a) protein, (b) moisture, (c) ash, (d) fat and (e) fiber content (%) of different bread samples. Different letters on bars represent significant differences among means.

3.3.3 Breads fat content

Fat content results are demonstrated in Fig. 2c; clearly, the control sample has the lowest fat content (0.65%) and adding *purslane* powder makes a significant change in fat content ($p<0.05$). That is, samples with 5%, 10%, and 15% *purslane* powder contain 1.01, 1.25, and 1.53% fat respectively. Taking into account the fatty nature of *purslane*, the increase in fat content is expectable. DESTA and MOLLA (2020) suggest that the highest oil content was observed in seed (DESTA, 2020) in the present study, all parts of the plant have been used. HOSSEIN and SALEM (2016) argued that increasing *purslane* powder in gluten-free stack formulations increased fat content significantly (HUSSIEN and SALEM, 2016). ASMA and GINDY (2017) studied the increase in fat content of breads through increasing *purslane* level in the formulation (ASMA and GINDY, 2017).

3.3.4 Total ash content of breads

Fig. 2d illustrates total mean ash content of the control and experiment samples. Clearly, the lowest ash content is observed with the control sample (2.85%) and since *purslane* powder contains higher levels of mineral elements, it yields more ash than wheat flour (ALAM, Juraimi, Yusop, Hamid, and Hakim, 2014). By increasing the share of *purslane* in the formulation, a significant increase in ash content takes place ($p<0.05$). The samples with 5%, 10%, and 15% of *purslane* powder yielded total ash volumes of 3.28%, 3.49%, and 3.68% respectively.

A study by IGLESIAS-PUIG *et al*. (2015) on the breads produced with quinoa total flour showed that with an increase in quinoa flour, ash content increases, which is consistent with our findings (IGLESIAS-PUIG *et al*., 2015).

A study by HOSSEIN and SALEM (2016) reported similar results so that an increase on *purslane* powder content in gluten-free snacks increased ash content of the products significantly (HUSSIEN and SALEM, 2016). ASMA and GINDY (2017) showed that an increase of *purslane* powder in bread formulation significantly increased ash content of the samples, which is consistent with our results (ASMA and GINDY, 2017). As the ash increases, the amount of minerals in the raw material increases (UDDIN, 2012).

3.3.5 Bread fiber content

Raw fiber content in the control and experiment samples is illustrated in Fig. 2e. Clearly, the higher fiber content of *purslane* powder compared to wheat flour increases the fiber content significantly ($p<0.05$). With an increase in *purslane* content in the sample, the fiber content increases significantly. The control sample have 0.69% fiber and the samples with 5%, 10%, and 15% *purslane* powder have 1.02, 1.32, and 1.59% fiber content respectively. HOSSEIN and SALEM (2016) showed that an increase in *purslane* powder content in gluten-free snack increased fiber content significantly (HUSSIEN and SALEM, 2016). A study by ASMA and GINDY (2017) showed that using *purslane* powder in the sample increased fiber content (ASMA and GINDY, 2017). ALMASOUD and EMAN (2014) consistently reported that adding *purslane* formulation to cracker increased fiber content notably (ALMASOUD and EMAN, 2014).

3.3.6 Sensory evaluation of bread

Mean scores of taste, texture, color, odor, and general acceptability of the samples are illustrated in Fig. 3.

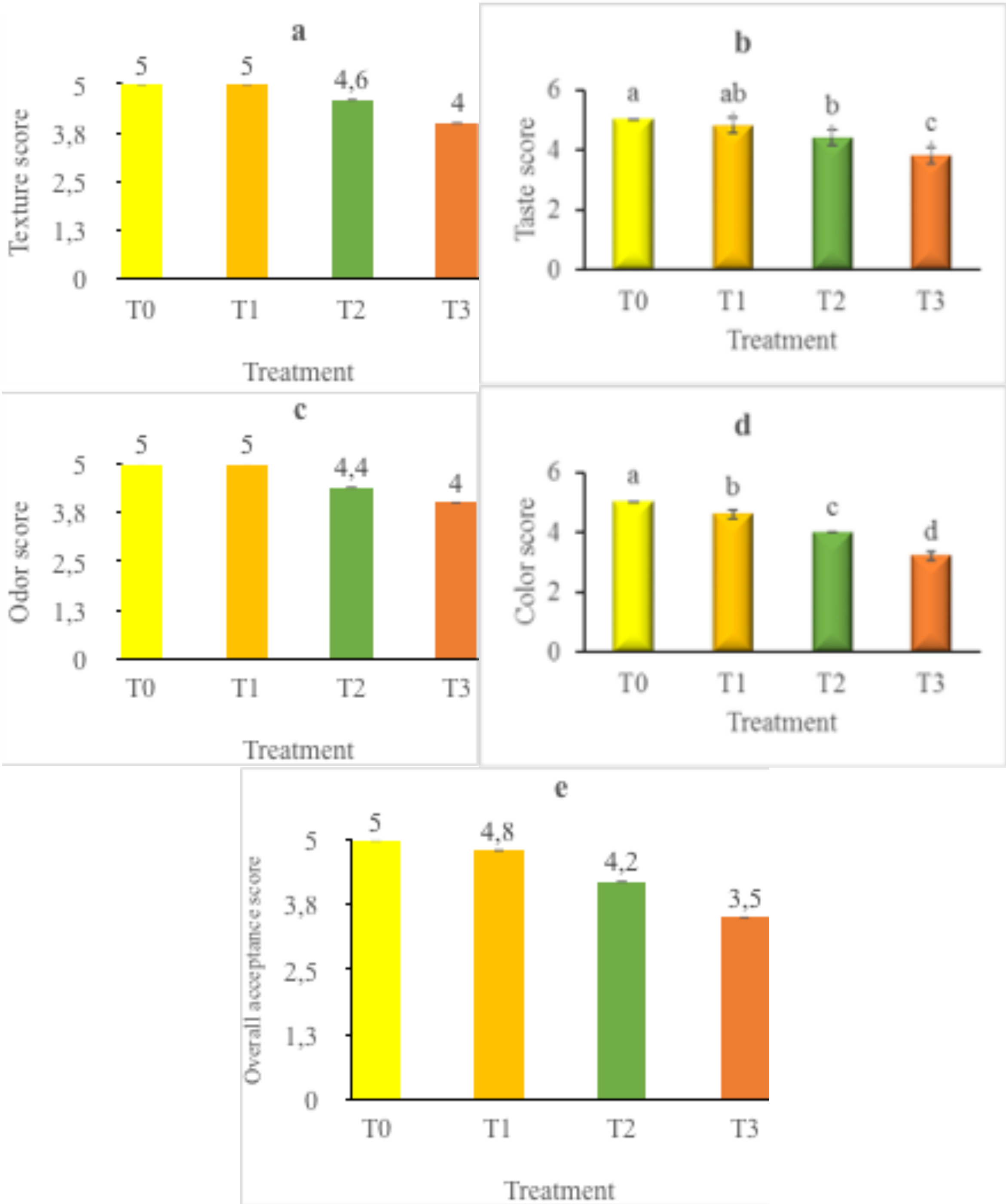

Figure 3. Comparison of (a) texture, (b) taste, (c) odor, (d) color and (e) overall acceptance score of different bread samples. Different letters on bars represent significant differences among means.

The control sample obtained the total score of taste, color, and general acceptability. In addition, the control and 5% samples obtained total score of texture and odor as well. Still, there was no significant difference between the control and 5% samples in terms of taste and general acceptability ($p>0.05$). Adding *purslane* powder to the bread formulation significantly lowered taste and general acceptability scores ($p<0.05$) so that the sample with 15% *purslane* content had the lowest score of color. Except for the 15% sample, the rest of the treatments were acceptable in terms of sensory indices. By increasing *purslane* content from 5% to 15%, texture, taste, and general acceptability scores declined ($p<0.05$) so that the 15% sample obtained the lowest scores of texture, odor, and general acceptability (FATHNEJHAD KAZEMI *et al*., 2012). Still, all the treatments were acceptable in terms of texture, odor, and general acceptability. High *purslane* content in the formulation decreased volume and moisture content of the breads and had a negative effect on the texture. The decrease in color score by adding *purslane* powder content can be explained by the dark color of *purslane* powder. HOSSEIN and SALEM (2016) showed that adding 5% of *purslane* powder had a significant effect on sensory acceptability of gluten-free snacks (HUSSIEN and SALEM, 2016). However, adding 10 and 15% of *purslane* powder resulted in a decrease in sensory score of products. However, all the enriched samples were acceptable in terms of sensory specifications. MERVAT *et al*. (2015) maintained that adding 10% of linseed flour with total fat content did not have a significant effect on sensory acceptability (MERVAT *et al*., 2015). GANORKAR and JAIN (2014) noted that dry crust, a decrease in tenderness, and feeling roughness in the mouth were the reasons for a decrease in general acceptability score after adding linseed to cookies formulation (GANORKAR and JAIN, 2014). These results show that increasing the additive content increases tenderness of the product due to the higher content of fatty acids content; however, color, odor, and general acceptability decrease, which is consistent with our results.
The reason for the noticeable decrease in the sensory score of the samples containing higher percentages of *Portulaca oleracea* was due to the black color of the *Portulaca oleracea* and its effect on the color of the bread samples. But in the MELILLI *et al*. (2020) study, the sensory score of 5% obtained the highest sensory score (MELILLI *et al*., 2020). It seems that this discrepancy is due to the difference of different varieties in different parts of the world and it is predicted that if the yellow varieties of portulaca are used, such a decrease will not be observed in fortified breads with a higher percentage of 10% *Portulaca oleracea*

4. CONCLUSION

hysicochemical, rheological, and sensory properties of voluminous wheat flour breads containing different levels of *purslane* powder were examined. An increase in *purslane* content in dough samples decreased DS against mixture and increased looseness level. Adding 15% of *purslane* powder decreased FQU significantly. In addition, despite the increase in extension strength and a significant decrease in dough extendibility, energy, and viscosity of the dough sample, the increase in GT was not notable. Moreover, increasing the content of *purslane* powder increased protein, fat, total ash, moisture, and fiber content of the samples compared to the control samples. In terms of sensory specifications, the samples with 15% *purslane* powder content obtained the lowest score and the rest of the samples obtained acceptable scores in terms of taste, texture, color, taste, and general acceptability. Using *purslane* in voluminous bread is feasible and the optimum formulation should contain 10% of *purslane* powder.

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