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ORIGINAL ARTICLE

Development of a functional food (pan bread) using amla fruit powder

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Abstract The amla fruit powders were analyzed for ascorbic acid, sugars, pectin, total phenolics (TPC), and total antioxidant activities (TEAC). Fresh amla was found to have 6644.305 mg/100 g ascorbic acid with sun-dried, oven-dried and freeze-dried having 748.427 mg/100 g, 641.364 mg/100 g, 791.233 mg/100 g, respectively. There were no significant differences for the TPC values which ranged from 113.1 for oven-dried (OD), 128.7 for sun-dried (SD), 161.2 mg for freeze-dried (FD) and 1410.5 GAE/g for fresh amla pulp (FA). The TEAC values ranged from 6.6 for OD, 6.8 for FD, 7.6 for SD and 116.4 mM/g for FA. The FD amla fruit powder had the highest total sugars (36.94%, db). The specific loaf volume of bread improved significantly (from 3.54 to 3.79 cc/g) as the level of SD or OD amla powder addition was raised to 0.25% but then decreased at higher level of addition (3.41 cc/g). However, in case of FD amla powder, the bread volume increased up to the addition level of 0.50% (4.09) then decreased slightly (3.95 cc/g) but was still significantly higher the SD and OD amla powders. Similarly, the TPC (from 0.32 to 1.16 mg GAE/g, db), TEAC (0.06–0.14 mM/g, db) and vitamin C (3.80–31.98 mg/100 g, db) contents also improved significantly as the level of amla powders were increased to 1%. The supplemented breads were well-accepted by the consumers. It can be concluded that amla supplemented pan bread with its superior nutritional and sensory qualities can be a possibility to improve consumer nutrition.

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Introduction

Demand for the medicinal plants is increasing in both the developing and developed countries due to a growing recognition that most natural products are non-toxic, have no side effects, and are easily available at affordable prices. Consequently, there is a growing demand for those natural foods which are rich in antioxidants, because these antioxidant compounds are known to help defend human body against many ailments, such as, heart disease, hardening of the arteries, inflammatory conditions, digestive and visual problems, arthritis, rheumatism, cancer and diabetes (Varnosfaderani et al. 2018). As the risk of these diseases is increasing worldwide and Kuwait being no exception, it becomes more necessary than ever to investigate the use of nutritionally-rich natural foods in the development of commonly consumed functional foods (Singh et al. 2016a; 2016b).

Amla fruit (*Phyllanthus emblica* L.), known as Indian Gooseberry, is widely cultivated in Pakistan, India, China, Sri Lanka, Indonesia and Malaysia. It is one of the most frequently used Ayurvedic herbs in the traditional medicine in India. It is quite sour, astringent tasting but is rich in ascorbic acid (Vitamin C) and a number of phenolic antioxidants. Because of its antiviral, antibacterial and antioxidative properties, it has been used as one of the principal constituents of Ayurveda system of medicine (Krishnaveni and Mirunalini 2010). Amla fruit is usually consumed as raw, pickle, jam, preserve, candy, powder and juice (Sidhu and Zafar 2012). Vitamin C content of amla

can vary depending on the varieties and is reported to range from 206.8 mg to 932.1 mg/100 g.

The pan bread and other baked goods prepared from white four constitute about 93% of the bakery products, whereas only a small amount of whole wheat flour products are consumed by the Kuwaiti population (Himmo and Al-Hooti 1993). It, therefore, offers a great opportunity to supplement this staple food (pan bread) with a highly nutritious amla fruit that is known to be rich in ascorbic acid and many other health-promoting phytochemicals (Raj et al. 2019).

Information on the use of amla fruit in bread making is scanty. However, a few workers have explored the use of other fruits and vegetables to make a number of functional foods. Kapoor et al. (2015a) have recently investigated the supplementation of Indian flat bread (known as *chapatti*) with *Jamun* powder (*Syzygium cumini* L.). According to them, *Jamun* fruit (Indian blackberry) is a minor crop but with robust medical benefits and possesses antioxidant, anticancer and anti-diabetic properties similar to that of amla fruit.

Although amla fruit is one of the richest sources of ascorbic acid (445–468 mg of vitamin C/100 g amla fruit) and has many phenolic compounds, but the sour and astringent taste makes the fresh amla fruit less acceptable to consumers (Nadheesha et al. 2007). Keeping in view the nutritional significance, the major objective of this study was directed to compare the effect of drying fresh amla fruit pulp by three different techniques i.e., hot-air drying (oven-drying), sun-drying, and freeze-drying for their effects on the proximate composition, ascorbic acid (vitamin C), pectin, total sugars, total phenolics, and the total antioxidant capacity. Secondly, amla fruit powder can also serve as a safer substitute antioxidant/improver for potassium bromate in pan bread making. Lastly, more importantly, the possibility of using differently dried amla fruit powders (SD: Sun-dried, OD: Oven-dried; FD: Freeze-dried) for the production of white flour pan bread (WB) with improved nutritional quality of this staple food was also investigated.

Materials and methods

Fresh amla fruit

Fresh amla fruit, which is imported from India, was procured from the local market. The fruit was washed thoroughly in running warm water to remove adhering dust and other impurities, paper-towel dried, seeds removed, pulped in a blender, and then taken for drying by three different methods.

Drying of amla fruit pulp

Fresh fruit pulp was spread thinly on aluminum foil, then sun-dried ($\sim$ 40 °C) in shaded corridor until the moisture content reached lower than 10% (took about 4 days). It was then powdered, labeled as sun-dried (SD) and stored at − 18 °C till further analyses and use. Kuwait has very hot summers where temperature could reach as high as 50 °C in the shaded areas. Fresh fruit was also dried in a hot air oven (Memmert, Germany) at 55 °C until the moisture content reached lower than 10%. It was then powdered, labeled as oven-dried (OD) and stored at − 18 °C till further analyses and use. Fresh fruit pulp was also freeze-dried (GAMMA 1-16 LSC, UK) until the moisture content reached lower than 2%. It was then powdered, labeled as freeze-dried (FD) and stored at − 18 °C till further analyses and use. Figure 1 shows the appearance of all three different types of amla powders as obtained after the drying operations.

Proximate analysis

Fresh amla fruit pulp was then used immediately for proximate analyses as well as for pectin, total phenolics, ascorbic acid and total antioxidant activity, as per procedures explained below. Moisture, ash, protein, fat and fiber in fresh as well as in dried amla samples were determined as per the standard AOAC procedures (AOAC 2010). The total acidity of fresh amla was determined by titrating the sample with standard 0.1N NaOH to pH 8.1 using a pH meter and expressed as % citric acid. The pH was measured using a Thermo Orion 410 A + (USA) pH meter. All the chemical used for analyses were of analytical grade. All the results for chemical analyses are expressed on dry basis (db).

Ascorbic acid

The ascorbic acid (Vitamin C) content was determined by the Ultra High-Performance Liquid Chromatography (UHPLC) (Shimadzu make, model UFLC Nexera X2, Japan). The procedure used was as described by Wright and Kader (1997) based on the method of Zapata and Dufour (1992). One g of the sample was stirred in 70% methanol for 1 h at room temperature under dark conditions. The samples were filtered through cheese cloth and then centrifuged at 10,000 rpm for 10 min. The remaining supernatant was passed through syringe filters (0.2 μm). The supernatant was dried under vacuum at room temperature with the help of a rotary evaporator. These samples were used for UHPLC analysis with appropriate dilutions according to the standard curve prepared from pure ascorbic acid.

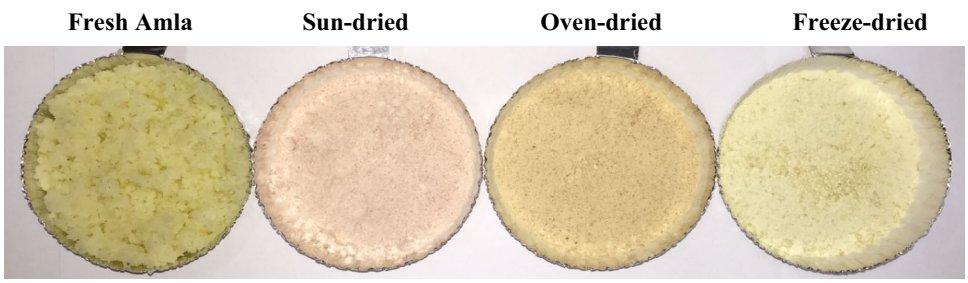

Fig. 1 Differently dried amla powders from fresh amla pulp

Antioxidant activity

As the various phytochemical compounds are known to possess antioxidative properties, Trolox Equivalent Antioxidant Capacity (TEAC) was measured as per the procedure reported earlier by Sidhu et al. (2019). The antioxidant assay was carried out by preparing all solutions in phosphate buffered saline (PBS) containing 5 mM phosphate buffer salts and 138 mM sodium chloride. Exactly 400 µM horse heart myoglobin was mixed with 0.244 mg/ml potassium ferricyanide in a 1:1 ratio. This mixture was purified by running it on a Sephadex G-25 packed column, loading 3.5 ml of mixture for a bed volume of 43 cm^3. Myoglobin fractions that started eluting after, the 16 one-ml fractions were collected. The absorbance of these myoglobin fractions was measured using Genesys5 spectrophotometer. All fractions with $A_{490} < 0.5$ were pooled together and the absorbances at 490, 560, 580, and 700 nm were measured. A_{700} was used as a correction factor hence it was deducted from the A_{490}, A_{560}, A_{580} readings. These corrected readings were then used for calculating the concentration of myoglobin using the following equation:

$$[\text{MetMb}]\ (\mu\text{M}) = 146A_{490} - 108A_{560} + 2.1\,A_{580}$$

Trolox, which is used as the antioxidant standard, was prepared in PBS with a concentration of 2.5 mM. 1 mM H_2O_2 is used to initiate the reaction. The standard curve was prepared by diluting the Trolox solutions. Exactly 0.50 g or 0.100 g of fresh or dried amla sample was dissolved in 1 ml of PBS buffer. Then it was centrifuged at $7000 \times g$ for 3 min to remove any particulate matter and the supernatant was used for the total antioxidant measurement assay as explained above.

Total phenolics

Total phenolic content (TPC) in fresh or freeze-dried amla samples was determined by the Folin-Ciocalteu method (Singleton et al. 1999). Known weight of sample was dissolved with methanol and made up the volume up to 100 ml. Then 0.5 ml of extract solution (taken in opaque flask) was mixed with 0.5 ml of the Folin-Ciocalteu reagent and then after 2 min, 0.5 ml of 100 mg/mL of sodium carbonate solution was added and allowed to stand for 2 h. The optical density of the blue-colored solution was measured in a spectrophotometer at 765 nm. The TPC was expressed as mg gallic acid equivalent (mg GAE/g) from the standard curve prepared by using pure gallic acid.

Sugar analysis

Fresh as well as dried amla samples were taken for glucose, fructose and sucrose analysis as per the method of Hudson et al. (1976). After homogenization of the sample, extraction of sugars was carried out with 80% ethanol. The extract was heated for some time and made up to the required volume. Separation and determination of the individual sugar are carried out with HPLC Shimadzu (LC 10AV) using NH_2 column (250 × 4.6 mm, 5 mm analytical column, and guard column), mobile phase acetonitrile: water (80:20) and refractive index detector (Shimadzu RI). Quantitative analysis is made using carbohydrate standards. The peak area of each component was measured and compared with that of a known standard to obtain quantitative results.

Total pectin

Total pectin, as calcium pectate, in the fresh and dried amla samples was estimated as per the modified method as reported in the Food and Drugs Laboratory manual, Ottawa, Canada (Ruck 1969).

Pan bread preparation

The white flour with 72% extraction was obtained from the Kuwait Flour Mills and Bakeries Co. These breads were made using the optimized straight-dough bread making method of the AACC (method 10-10B, AACC 2000) with slight modifications. The control bread was made with WF (14% moisture level) using all other ingredients on the basis of flour: sucrose (6%), salt (1.5%), shortening (3%), Non-Fat Dried Milk (4%), active dry yeast (1.75%). WF was used as a control while varying levels of dried amla powders at 0.25, 0.5 and 1% level were added to the test

breads. Water absorption was optimized by adding as much water as possible while still keeping the dough manageable. Bread making was replicated thrice on three separate days, and the average values are reported. The bread immediately removed from the oven (219 °C), was weighed, and loaf volume was measured by the rapeseed replacement method. Specific loaf volume and baking loss were then calculated.

Chemical analysis of bread samples

All the bread samples were freeze-dried and powdered in a Falling Number Mill (Model 3100, Perten Instruments AB, Sweden) to pass thru a 100-mesh sieve and stored in airtight containers in a refrigerator till further chemical analyses. These bread samples were analyzed for ascorbic acid, total phenolics and antioxidant activity as per the methods reported earlier in foregoing section.

Sensory evaluation of pan bread

Sensory analysis was performed on the same day of the bake after cooling the bread samples to room temperature. The bread samples were kept in airtight packages in a room at 20 ± 2 °C. Ten semi-trained panelists of both sexes aged 18–50 years were enlisted for the test. The test, using a 9-point hedonic scale, questioned their preferences/acceptance for crumb color, flavor and texture (Ishida and Steel 2014).

Statistical analysis

All of the above chemical analyses results have been expressed on dry basis (db). All of the research data were statistically analyzed using the software: IBM SPSS statistics (Version 21 software Inc. Chicago, USA). Significant differences between the mean values were evaluated with one-way analysis of variance (ANOVA) followed by Tukey's posthoc multiple comparisons test. A value of alpha level at $p < 0.05$ was considered to be statistically significant. Results are presented as Mean ± SD.

Results and discussion

Fresh amla fruit procured from the local market as well as dried amla powders were analyzed for proximate composition, and antioxidant capacity. White flour bread (WB) made with amla powders was analyzed for proximate composition, TEAC, TPC, baking quality and sensory characteristics. The results obtained from this study are presented and discussed in the following sections.

Proximate analysis

The total acidity and pH of fresh amla fruit were found to be 1.6% (as citric acid) and 2.85, respectively. No significant differences ($p > 0.05$) were observed between each of the other chemical constituents of these amla powders. The, crude ash in SD, OD and FD amla powders was 1.99, 2.35 and 2.36% (db), respectively. The crude fat, crude protein, crude fiber and pectin contents ranged from 2.53 to 2.60, 2.96 to 3.26, 8.23 to 9.98 and 0.33 to 0.43% (db), respectively. Obviously, the three drying methods did not affect the proximate analysis values significantly.

Sugar analysis of amla powders

Amla fruit powders were analyzed only for fructose, glucose and total sugars. Among the three powders, FD had the highest amount of sugars followed by SD and the least amount was in OD (Table 1). This may possibly be due to the higher temperature that the OD sample has gone through during the drying operations. The higher temperature reached during oven drying can lead to browning changes in sugars, mainly because of the fructose caramelization, Maillard reaction and enzymatic degradation (Arslan and Özcan 2010). Because of very low temperature reached during the freeze-drying operation, no sugar was involved in browning reactions, thus giving the lightest color and the highest sugar values in FD sample.

Browning reactions taking place during food dehydration and are known to affect color, decrease nutritional value and solubility, create off flavors, and induce textural changes. Browning reactions depend on the temperature used during drying operations, pH and moisture content of the product, total time of heat treatment, the concentration and nature of the reactants (Manzocco et al. 2000). Because amla fruit is low in polyphenoloxidase enzymes, the enzymatic browning reactions are of lower importance. However, three main non-enzymatic browning reaction pathways have been suggested: (i) Maillard reaction, (ii) Caramelization, (iii) Ascorbic acid oxidation (Manzocco et al. 2000). Obviously, the freeze-drying is considered a better method for drying as it reduces the risk of such

Table 1 Sugar analysis of amla powders (%, Mean ± SD, dry weight basis)

Amla powder	Fructose	Glucose	Total sugars
SD	$10.03 \pm .02^{a}$	6.21 ± 0.02^{d}	$16.24 \pm .01^{g}$
OD	$9.15 \pm .01^{b}$	6.72 ± 0.02^{e}	$15.75 \pm .01^{h}$
FD	$22.39 \pm .01^{c}$	$14.54 \pm .01^{f}$	$36.94 \pm .01^{i}$

Mean values with different superscripts differ significantly ($p < 0.05$) between rows in each constituent

reactions thereby retaining nutritive value as well as the physiological attributes of the fruit so treated. However, freeze-drying is known to be an expensive method and is economically feasible only for highly flavor-sensitive foods (Krokida et al. 2001) and not for common fruits like amla.

Analysis of amla powders for vitamin C, TPC and TEAC

Fresh amla fruit as well as dried amla fruit powders showed a significant variations in the vitamin C, TPC and TEAC contents. These values were the highest in fresh amla pulp (Table 2) when compared with the dried samples. The vitamin C content in fresh amla pulp got reduced significantly when it was dried either in the sun (SD) or in the hot air oven (OD), obviously, vitamin C being a heat labile nutrient, was lost during the drying operations. Ascorbic acid being the most sensitive constituent in amla fruit has been reported to get destroyed even during high pressure processing (HPP) where temperature rise is much lower during the processing operation (Raj et al. 2019). Some of the other antioxidants (e.g., phenolics) may have been lost or have reacted with the protein components of amla fruit during the exposure to heat and the oxygen environment, thus giving low values. Between the powders, FD had significantly higher vitamin C content because there wasn't any exposure to heat and oxygen, as was the case with SD and OD samples. Surprisingly, there weren't any significant differences in TPC and TEAC values between these three powders. Interestingly, the total phenolics content of amla juice has been shown to increase during the HPP treatment, as more phenolics became extractable (Raj et al. 2019). The enhanced TEAC values in dried amla samples may possibly be due the generation of additional antioxidant compounds through browning reactions during the drying process (Hrynets et al. 2019). Although, the TPC was the highest in FD, followed by SD and OD, but differences were not significant statistically. Similarly, SD had the highest TEAC value, followed by FD and the OD powders. Again, none of these differences were significant ($p > 0.05$). Similar analytical results on solar dried amla samples have been reported earlier by Pareek and Kaushik (2012).

Table 2 Analysis of Amla Powders for Vitamin C, TPC and TEAC (Mean ± SD, db)

Amla	Vitamin C mg/100 g	TPC mg GAE/g	TEAC mM/g
FA	6644.3 ± 6.9^{a}	1410.5 ± 86.0^{e}	116.4 ± 6.5^{j}
SD	748.4 ± 6.3^{b}	128.7 ± 3.1^{f}	7.6 ± 1.3^{k}
OD	641.3 ± 4.4^{c}	113.1 ± 25.9^{g}	6.6 ± 1.9^{m}
FD	791.2 ± 1.7^{d}	161.2 ± 1.6^{h}	6.8 ± 1.5^{n}

Mean values with different superscripts differ significantly ($p < 0.05$) between rows in each constituent

**GAE* Gallic acid equivalents

Kaur and Kapoor (2002) have reported that more than 70% of antioxidant activities in amla fruits were correlated positively with total phenolic contents. Scartezzini et al. (2006) have reported that the ascorbic acid in dried amla powders contributes only about 60% or even less of the antioxidant activity, and the contribution of other constituents increases. The loss in vitamin C content during drying is possibly due to oxidation and polymerization into browning pigments. In the presence of oxygen and heat, the ascorbic acid is easily oxidized to dehydroascorbic acid (Behrens and Madere 1987). In addition to the loss of vitamin C due to effect of high temperature during drying, the loss can also occur due to chemical degradation during the preparation step in pulping the amla fruit, where oxygen gets incorporated into the pulp during maceration process. There is also a possibility that significant loss of vitamin C may also occur by leaching of juice from freshly pulped fruit on to the drying tray. Certain amount of loss can also occur during the storage and handling operations of amla powders (Thankitsunthorn et al. 2009).

Usually, when food samples are dried, some degradation of phytochemicals can occur due to non-optimal drying conditions. However, under certain situations, drying may not reduce the quantity of these compounds but may in turn protect these compounds (Lim and Murtijaya 2007). Harbourne et al. (2009) have shown that the temperature of drying can lead to noticeable decline in phytochemicals, depending on the plant species. The lowest values for OD can be explained by the influence of drying operation as heat might have caused enzymatic and thermal degradation of the phenolic compounds. Some researchers report that the activity of the enzyme polyphenol oxidase declined after heat treatment thus explaining the decline in TPC during the initial stages of drying operation (Lim and Murtijaya 2007). As the air inlet temperature increased from 125 to 200 °C, the TPC and the free radical scavenging activity decreased significantly up to a temperature of 175 °C during spray drying of amla juice (Mishra et al. 2014). However, the TPC increased after this temperature. Recently, polyphenolic compounds in many fruits such as jambolan (Syzygium cumini) have been shown to possess not only antioxidant but also antimicrobial properties which can exploited for use in the development of functional foods (Singh et al. 2016b).

Due to the low temperature used for drying operation, the FD amla powder had significantly higher vitamin C content (791.2 mg/100 g), TPC (161.2 mg GAE/g), followed by SD and OD amla powders (Table 3). Absence of exposure to heat during the preparation of FD powder as

Table 3 Vitamin C, TPC and TEAC Analyses of pan bread samples (Mean ± SD, db)

Constituents (%)	Amla powder	Level of amla powder addition (%)			
		Control (0)	0.25	0.50	1.0
Vitamin C, mg/100 g	SD	3.80 ± 0.6^{a}	$6.51 \pm 1.3^{b}_{m}$	$9.46 \pm 0.7^{c}_{p}$	$29.54 \pm 0.7^{d}_{r}$
	OD	3.80 ± 0.6^{e}	$4.28 \pm 0.4^{e}_{n}$	$7.54 \pm 0.5^{e}_{q}$	$22.40 \pm 0.4^{f}_{s}$
	FD	3.80 ± 0.6^{g}	$6.91 \pm 1.1^{h}_{m}$	$10.93 \pm 0.4^{j}_{p}$	$31.98 \pm 2.0^{k}_{t}$
TPC (as mg GAE/g)*	SD	0.32 ± 0.04^{a}	$0.37 \pm 0.03^{a}_{h}$	$0.40 \pm 0.07^{a}_{j}$	$1.05 \pm 0.06^{b}_{m}$
	OD	0.32 ± 0.04^{c}	$0.34 \pm 0.03^{c}_{h}$	$0.38 \pm 0.01^{c}_{j}$	$0.75 \pm 0.04^{d}_{n}$
	FD	0.32 ± 0.04^{e}	$0.40 \pm 0.06^{e}_{h}$	$0.71 \pm 0.05^{f}_{k}$	$1.16 \pm 0.02^{g}_{p}$
TEAC, mM/g	SD	0.06 ± 0.01^{a}	$0.04 \pm 0.01^{a}_{h}$	$0.06 \pm 0.01^{a}_{k}$	$0.13 \pm 0.01^{b}_{n}$
	OD	0.06 ± 0.01^{c}	$0.03 \pm 0.01^{c}_{j}$	$0.07 \pm 0.01^{c}_{k}$	$0.11 \pm 0.01^{d}_{p}$
	FD	0.06 ± 0.01^{e}	$0.05 \pm 0.00^{e}_{h}$	$0.09 \pm 0.01^{f}_{m}$	$0.14 \pm 0.01^{g}_{n}$

Mean values with different superscripts differ significantly ($p < 0.05$) in a row for each constituent

Mean values with different subscripts differ significantly ($p < 0.05$) in a column for each constituent

**GAE* Gallic acid equivalent

compared to higher temperatures of drying in SD and OD amla powders, could explain the better retention of vitamin C and phenolics in the FD amla powder. However, it is difficult to explain the changes in the TEAC values of differently dried amla powder, as a number of compounds are reported to develop by the Maillard reaction which has been shown to have antioxidant properties (Tanaka et al. 1990; Manzocco et al. 2000;). These workers have studied the browning reactions in a model system, but bread environment is quite complex. That makes it difficult to explain these differences in TEAC values. These have pointed out that the antioxidant activity decreases in early stages of browning but recovers during later stages of heating. Some of the naturally occurring antioxidants (such as carotenoids) are more stable than the ascorbic acid, a prime antioxidant compound in amla fruit.

Analysis of pan bread made with amla powders

The ash, protein, fat and fiber values did not vary significantly in bread samples, with the increased level of amla powders addition. As the level of amla powder ranged from 0.25 to 1.0%, the contribution of amla powder towards increasing the ash, crude fat, crude protein and crude fiber contents would obviously be negligible. Amla fruit is not a very rich source of minerals, fat or proteins.

Vitamin C, TPC and TEAC analysis

In case of bread samples made with different levels of amla powder addition, a significant increase in vitamin C content was observed but only at the 1% level of addition. The highest amount of vitamin C content was observed in bread sample made with FD (31.98), followed by SD (29.94) and OD (22.4 mg/100 g) amla powder (Table 3). Most of the vitamin C that was present in the amla powders was retained during the baking process as the bread dough has anaerobic environment due to the presence of carbon dioxide produced by the yeast. Most of the vitamin C survived the baking process. For TPC, the retention of phenolics in breads made with 1% of SD, OD and FD amla powders was found to be 64.8, 51.7 and 60.1%, respectively. It seems that a lot of phenolics were lost due to pyrolysis during the bread baking process. Baking process has been shown to reduce some of the constituents during bread manufacture (Kapoor et al. 2015b). In case of bread made with 1% of the SD, OD and FD amla powders, the TEAC values were found to deviate from the original values by − 4.4% (decrease), − 12.7% (decrease) and 9.4% (increase) in the finished bread, respectively. It can be speculated that certain amount of antioxidant compounds were formed by the Maillard reactions during baking to increase the TEAC value in bread made with FD amla powder, but due to higher amounts of already pyrolyzed/degraded phenolics during drying of OD and SD amla powders resulted in lowered TEAC values in these two samples of bread after baking. This complex set of reactions may lead to increase and then decrease in the values of TEAC observed in our bread samples. The use of black carrot dietary fiber concentrate and xanthan gum has been utilized to produce acceptable eggless gluten-free rice muffins, a popular bakery product having health promoting properties (Singh et al. 2016a).

Baking properties of WF bread with amla powders

Loaf volume is a very desirable characteristic affecting the consumer acceptability of the pan bread. Bread volume measured by rapeseed replacement method was converted into specific loaf volume and the data are presented in

Table 4 Effect of amla powder addition on the baking properties of pan bread (Mean ± SD, db)

Parameter	Amla powder sample	Level of amla powder addition (%)			
		Control (0)	0.25	0.50	1.0
Specific Loaf Volume, cc/g	SD	3.54 ± 0.01^{a}	$3.73 \pm 0.07^{b}_{m}$	$3.41 \pm 0.01^{c}_{p}$	$3.41 \pm 0.06^{c}_{s}$
	OD	3.54 ± 0.01^{d}	$3.79 \pm 0.01^{e}_{n}$	$3.66 \pm 0.09^{f}_{q}$	$3.54 \pm 0.05^{d}_{t}$
	FD	3.54 ± 0.01^{g}	$3.78 \pm 0.06^{h}_{n}$	$4.09 \pm 0.01^{j}_{r}$	$3.95 \pm 0.04^{k}_{u}$
Baking loss, %	SD	11.20 ± 0.16^{a}	$12.10 \pm 0.05^{b}_{m}$	$13.68 \pm 0.09^{c}_{p}$	$13.20 \pm 0.09^{c}_{s}$
	OD	11.20 ± 0.16^{d}	$12.78 \pm 0.06^{e}_{n}$	$13.35 \pm 0.15^{f}_{q}$	$12.74 \pm 0.04^{e}_{t}$
	FD	11.20 ± 0.16^{g}	$12.05 \pm 0.04^{h}_{m}$	$14.91 \pm 0.11^{j}_{r}$	$13.12 \pm 0.08^{k}_{s}$

Mean values with different superscripts differ significantly ($p < 0.05$) in a row for each parameter

Mean values with different subscripts differ significantly ($p < 0.05$) in a column for each parameter

Table 4. No noticeable differences in the outside appearance of bread baked with SD amla powder were observed. Overall, the specific loaf volume of the amla powder supplemented WB was higher than the control bread. As the supplementation level increased, the specific loaf volume decreased in case of bread made with both the SD and OD amla powder. However, for FD amla powder, there was a significant increase ($p < 0.05$) in comparison with the control sample. The highest specific volume was obtained with a 0.5% level of FD amla powder supplementation. There was no specific trend across the same level in the other bread samples, except at a 1% level of amla powder supplementation as the specific loaf volume followed a decreasing trend from the highest for FD, then OD and to the lowest for SD amla powder. Compared with control, the crumb grain of WB made with amla powders became coarser and more open.

Higher specific volume for FD might be due to a higher ascorbic acid in this powder. Higher level of oxidizing chemicals have been reported to weaken gluten proteins by oxidizing tripeptide glutathione, which is, otherwise, known for its strong reducing properties, thus these oxidants minimize the deleterious effects of glutathione on dough quality. These oxidants have been shown to react with –SH group of gluten proteins during dough mixing (Sidhu et al. 2001). Some of the ascorbic acid is utilized as an oxidizing agent when it is converted to dehydroascorbic acid by the enzyme ascorbic acid oxidase in the presence of oxygen available in the dough (Schroeder and Hoseney 1978), whereas most of it remains as ascorbic acid in the dough. The remaining amount of ascorbic acid will serve as a source of antioxidant vitamin for the bread consumers. Our results in Table 4 show that the certain amount of ascorbic acid survives the baking process. Due to absence of oxygen in the bread dough going into baking oven could be the reason for the retention of ascorbic acid in the baked bread. Baking loss % was found to be slightly higher in the supplemented breads than in the control but was statistically insignificant ($p < 0.05$).

Sensory analysis of pan bread

Sensory analysis of the pan bread samples prepared with the addition of amla powders was carried out on a 9-point hedonic scale, ranging from 1-disliked extremely to 9-liked extremely. No significant difference was observed in any of the sensory attributes, i.e., color, taste and texture, among all the bread samples made with varying levels of amla powders. The scores were slightly lower at the highest level of supplementation (1%), but the differences were statistically insignificant. In case of bread made with SD and OD amla powder, showed a little less acceptability (but statistically insignificant) when compared to the bread made with FD amla powder. This may probably be due to the darker color, an astringent taste and a little firmer texture in SD and OD samples. The bread samples made with 1% amla powder had a slightly astringent and sour aftertaste, as reported by some of the panelists. However, as suggested by some earlier workers (Sadji et al. 2018), the astringent taste problem could be solved by using certain other fruits/vegetables with superior nutritional qualities and sweeter taste (such as carrots, grapes, watermelon), that could balance out the taste and color of the bread for better acceptability. On the whole, the panelists rated all the pan bread samples as liked very much.

Conclusion

At the level of amla powder addition up to 1%, the proximate composition (ash, crude fat, crude protein and crude fiber contents) of bread samples was not affected significantly. Fresh amla was found to have 6644.305 mg/100 g ascorbic acid with sun-dried, oven-dried and freeze-dried

having 748.427 mg/100 g, 641.364 mg/100 g, 791.233 mg/100 g, respectively. However, the specific loaf volume, and baking loss were affected significantly as the level of SD or OD amla powder addition was raised to 0.25% but then decreased at higher level of addition. The specific loaf volume of bread improved significantly (from 3.54 to 3.79 cc/g) as the level of SD or OD amla powder addition was to 0.25% but then decreased at higher level of addition (3.41 cc/g). The amla powder supplemented breads which were well accepted by the panelists showed potential to serve as a staple functional food among the local consumers. However, further research is needed to find ways to overcome the astringency and sour taste imparted by the amla powders when incorporated into the pan bread.

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