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Effect of extruded finger millet (*Eleusine coracan L.*) on textural properties and sensory acceptability of composite bread

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ABSTRACT

Inclusion of native millet flour in refined wheat flour negatively affects the technological, textural and sensory properties of composite breads. The present study explores the potential of extruded finger millet flour in improving the quality of composite bread. Composite doughs with extruded finger millet were significantly ($p < 0.05$) less firm and more extensible than their counterparts with unextruded flour. Breads elaborated from extruded finger millet (BEF) had better technological properties (higher specific volume and loaf height), good texture (low hardness, high resilience, low chewiness) than breads elaborated from unextruded finger millet (BUF). Furthermore, phenolic content and antioxidant activity of BEF was significantly improved ($p < 0.05$) in comparison with the BUF and control bread. Sensory panel showed high preference for brown colour of composite breads (BUF and BEF) over control bread. Sensory scores of BEF were significantly ($p < 0.05$) higher than BUF, accounting for an overall high acceptability (8.5) of BEF20 (20 g/100 g substitution level) at par with control bread. Results strongly suggest that use extruded finger millet (20 g/100 g) is an effective way of enhancing phenolics, antioxidant activity, texture and sensory quality of composite bread.

1. Introduction

The current demand for novel and healthy foods together with the increasing lifestyle diseases has dramatically driven a new market for bakery products using alternative flours to wheat. In this context, the unique nutritional profile of millets comprising of high dietary fibre, micronutrients, non-gluten proteins and phytochemicals deserves special attention in bread making applications (Angioloni & Collar, 2012a). The common wheat bread available in market is made from refined flour has high glycemic load and lacks in phenolics, dietary fibre and micronutrients (Ho, Aziz, & Azahari, 2013). Substitution of refined bread flour with non-gluten millets and psuedocereals is an effective way to deliver fibre and phytochemicals to enhance phenolic and antioxidant activity in final product (Koletta, Irakli, Papageorgiou, & Skendi, 2014; Schoenlechner, Szatmari, Bagdi, & Tomoskozi, 2013).

Finger millet (*Eleusine coracana L.*) is nutritious coarse cereal; rich in protein, crude fibre, calcium, and phenolics than wheat. High phenolic content is known to have cholesterol lowering properties and helps regulate glucose homeostasis by inhibiting pancreatic amylase and intestinal α-glucosidase activity, hence useful in managing type-2 diabetes (Krishnan, Dharmaraj, Manohar, & Malleshi, 2011). Finger millet can therefore be used as a functional ingredient in composite breads. Incorporation of raw or unprocessed non-gluten flour can seriously affect the textural as well as technological properties of breads such as low gas retention, poor crumb texture and faster staling. Various approaches have been successfully employed to overcome these defects by using technological additives such as gluten, enzymes, hydrocolloids, starches or physical hydrothermal treatments (Angioloni & Collar, 2012b; Ho & Aziz, 2013; Martinez, Oliete, & Gomez, 2013b; Schoenlechner et al., 2013).

Extrusion is an important hydrothermal treatment, which modifies flour functionality by way of gelatinization and degradation of starch, solubilization of dietary fibre and protein aggregation. In this regard, extruded flours are interesting alternatives to pre-gelatinized starch and hydrocolloids to increase bread output in the bakery industry (Martinez, Oliete, Roman, & Gomez, 2014a). Positive effects of extruded wheat flour, wheat bran, cassava flour and rice flour on technological, textural and sensory properties of gluten and gluten-free breads have been recently demonstrated (Gomez, Jimenez, Ruiz, & Oliete, 2011; Martinez et al., 2013b, 2014a; Ortolan et al., 2015). However, to the best of our knowledge, there is no report on use of extruded finger millet for bread making. Against this background, the present investigation was carried to examine the potential of extruded finger millet flour in composite bread.

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2. Material and methods

2.1. Flour preparation

The wheat grains of variety HD-3090 (moisture: 14.13%, ash: 0.91%, protein: 13.3%, gluten index: 59, water absorption: 59.3%, dough development time: 3.4 min and dough stability: 3.8 min) developed by ICAR-Indian Agricultural Research Institute, New Delhi, India, were procured. Finger millet grains of variety MR2 were generously provided by AICRP on small millets, Bangalore, India. Both wheat and finger millet grains were milled and screened through 35 mesh sieve. The proximate composition of finger millet flour was – moisture: 8.99%, ash: 3.51%, protein: 6.88%, crude fat: 1.57%, crude fibre: 3.43% and carbohydrate: 75.62%.

Prior to extrusion, the finger millet flour was preconditioned by spraying with a calculated amount of water and mixing continuously at medium speed in a blender to reach final moisture content to 20% (wb). The moistened flour was allowed to stay overnight in polyethylene pouches to equilibrate at room temperature. Extrusion was performed using laboratory-scale co-rotating twin screw extruder (M/S. BTPL, Kolkata, India) with specifications of barrel diameter (30 mm), screw length (450 mm), and die opening (3 mm). The steps include feeding preconditioned flour with 20% (wb) moisture content to the extruder at a 20 rpm constant feeder speed, 110 °C barrel temperature, 350 rpm screw speed and extruding the plasticized mass through die orifice to form an extrudate without jamming the extruder. Extrusion conditions were selected on the basis of preliminary trials. The expelled hot extrudates were fed directly into a tray drier, maintained at 60 °C. The final dried samples were ground and sieved through 80 mesh sieve. The extruded finger millet flour was analysed for its proximate composition (moisture: 5.4%, ash: 3.78%, protein: 7.2%, crude fat: 1.55%, crude fibre: 3.49% and carbohydrate: 78.58%).

Six formulations of composite flour were prepared using refined wheat flour, substituted with unextruded and extruded finger millet flour, each at three levels (10, 20 and 30 g/100 g). The composite flours containing different levels of unextruded and extruded finger millet flour were designated as CUF (CUF10, CUF20, CUF30) and CEF (CEF10, CEF20, CEF30) respectively. The corresponding breads elaborated from composites were designated as BUF (BUF10, BUF20, BUF30) and BEF (BEF10, BEF20, BEF30). Refined wheat flour served as control.

2.2. Bread elaboration

A straight dough method was used for the preparation of composite breads (CUF and CEF). All the ingredients such as compressed yeast (4%), sugar (4%), milk powder (4%), salt (1.6%) and improver; DATEM (Diacetyl Tartaric Acid Esters of Mono and Diglycerides) (0.6%) were added and mixed in laboratory dough mixer (National Manufacturing Company, Lincoln, United States) for about 5–7 min at slow-medium speed. In case of composite flours, additional mixing time of 5 min was given to achieve similar smoothness and homogeneity of dough similar to that of normal wheat bread. After mixing all the ingredients, the dough was placed in oiled mould ($20 \times 10 \times 6$ cm) into a loaf shape and kept in proofer (Widsons Scientific Works, India) at 40 °C and 85% RH for 40 min when the dough level rose to the top level of mould. The proofing of dough was measured by measuring dough height using graduated scale. Duplicate samples of 10 ml dough of each recipe were placed in a 250 ml beaker and left for 50 min incubation at 35 °C. Following fermentation, dough was baked for 200 °C for 30 min in baking oven (Widsons Scientific Works, India), loaves de-panned and cooled for about 90 min at room temperature, weighed and packed in polyethylene bags and refrigerated till analysis.

The water in each formulation was the amount of water required for the dough to reach 500 BU of consistency in the farinograph (Control: 52 g/100 g, CUF10: 54 g/100 g, CUF20: 55 g/100 g, CUF30: 57 g/100 g, CEF10: 59 g/100 g, CEF20: 61 g/100 g and CEF30: 64 g/100 g). Preliminary tests were performed, which aimed at the production of breads with maximum volume (data not shown).

2.3. Chemical composition

Proximate composition of flours was determined using AACC International Methods (AACC, 2000): moisture, method 44-15A; ash, method 08-01; protein, method 46-08; crude fat, method 30-10 and crude fibre, method 32-10.

Water absorption index (WAI) of composite flours was determined by the method of Gujral and Singh (2002) and calculated as:

$$WAI(g/g) = \frac{Weight\ \ of\ \ sediments}{weight\ \ of\ \ dry\ \ solids}$$

2.4. Pasting properties of flour

The pasting properties of composite flours were performed in triplicate according to AACC international method: 76-21.0 (AACC, 2000) (3.5 g flour, 14% moisture basis) with slight modification using Rapid Visco Analyzer (RVA) (MCR 52, Anton paar, Austria). The flour-water suspension was held in the RVA at 50 °C for 1 min, heated from 50 °C to 95 °C @12 °C /min, held at 95 °C for 2.5 min, cooled to 50 °C @12 °C/min, and held at 50 °C for 2 min. The shearing rate was 960 rpm for the first 10 s followed by 160 rpm until the end of the analysis. The pasting temperature, peak viscosity, breakdown, final viscosity and setback of the flour were identified from the pasting curve using Thermocline Version 2.2 software (Newport Scientific, Warriewood, NSW and Australia).

2.5. Textural properties of dough

Textural properties of doughs were measured in terms of firmness, extensibility and stickiness. Dough firmness was determined according to AACC international method: 74-10.02 (AACC, 2000) by texture analyzer (TA-XT2, Stable Micro Systems, Surrey, UK) using 49 N load cell, 36 mm diameter cylinder probe with pre and post-test speed of 1 mm/s and 10 mm/s respectively.

Dough extensibility was measured by texture analyzer (TA-XT2) equipped with SMS/Kieffer dough extensibility rig (Kieffer et al., 1998). The test accessory was 49 N load cell with pre-test speed: 2 mm/s, post-test speed: 10 mm/s; distance: 75 mm, trigger force: auto – 0.049 N; data rate acquisition: 200 point per second. More than 15 dough strips were tested from each type of dough.

Dough stickiness was measured by texture analyzer with a modified SMS/Chen-Hoseney stickiness rig (Chen & Hoseney, 1995); using accessories such as 49 N load cell, 25 mm perspex cylinder probe (P/25P) and dough stickiness cell (A/DSC).

2.6. Technological properties of bread

The bread specific volume of was measured by small seeds displacement method described by Lopez, Pereira, & Junqueira (2004).

A digital vernier calliper was used to measure loaf height at three equidistant places (at centre and at 45 mm on both sides from centre).

The evaluation of bread moisture was performed using AACC International Method 44-15 (AACC, 2000).