LWT - Food Science and Technology 48 (2012) 276–282

Contents lists available at SciVerse ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Fuzzy analysis of sensory attributes of bread prepared from millet-based composite flours

K.P. Singh [a], Abhinav Mishra [b,*], H.N. Mishra [b]

[a] Central Institute of Agricultural Engineering, Bhopal 462038, India
[b] Indian Institute of Technology, Agricultural and Food Engineering Department, Kharagpur 721302, West Bengal, India

ARTICLE INFO

Article history:
Received 21 June 2011
Received in revised form
29 March 2012
Accepted 30 March 2012

Keywords:
Sensory evaluation
Fuzzy logic
Composite flour
Bread
Millet

ABSTRACT

Millets have various nutrition qualities, and have rightly been called “nutri-cereals”. Wheat is traditionally used in breads, and consumption of millet can be increased by replacing wheat by millet to a required extent. The aim of this study was to optimize millet-based composite flours for the preparation of breads. Barnyard-millet and wheat composite flour (BWCF) was formulated and prepared by mixing 61.8 g/100 g barnyard-millet, 31.4 g/100 g wheat and 6.8 g/100 g gluten. Another formulation barnyard-millet, finger-millet, proso-millet and wheat composite flour (BFPWCF) was developed using 9.1 g/100 g barnyard, 10.1 g/100 g finger-millet, 10.2 g/100 g proso-millet and 69.6 g/100 g wheat. Bread samples were prepared using two composite flours and wheat flour, which was used to compare the quality of the breads prepared from the composite flours. A sensory study was conducted for analysis of acceptability of these samples. The analysis of this sensory study was conducted using fuzzy logic. The results of sensory analysis showed that the acceptability of bread samples prepared from composite flours was almost equal to the wheat bread.

1. Introduction

1.1. Nutritional benefits of millets and importance of baking

Millets have been used as important staples worldwide for centuries. Apart from health benefits, millets are also good source of energy, protein, vitamins and minerals (Rao, 1986). Millets proteins are good sources of essential amino acids except lysine and threonine but are relatively high in methionine. These are rich sources of phytochemical and micronutrients and hence, they are termed as “nutri–cereals”. Barnyard-millet is three times richer in minerals as compared to wheat and four times richer in fat, seven times richer in minerals and twice richer in calcium as compared to rice. The grains of barnyard-millet are low in phytic acid and rich in iron and calcium. Some varieties of millets are better in protein, oil and mineral content, but their use in the diet is limited because they are difficult to process and lack in gluten and grittiness (Malleshi, 1986). Development of suitable processing methods for small millets and nutritious food products is essential to promote utilization of these millets in India where nearly 63 percent children under five years of age are malnourished. Bread, biscuits and cakes are traditionally made from wheat flour. The percentage of millet blend can be increased by adding some external gluten in the composite flour. Apart from good nutritional values, millet foods are also known for their low glycemic index (Singh, Mishra, & Saha, 2010c). The increase in percentage of millet will decrease the GI of the composite flour which may be beneficial for the persons suffering from heart disease, diabetes and hypertension. Hence, providing the millet similar to rice, wheat or in the form of ready-to-eat convenience cereal would improve its acceptability (Saha et al., 2011).

Baking is important because several fundamental complex physical processes are coupled during baking, such as, evaporation of water, volume expansion, gelatinization of starch, denaturation of protein and crust formation etc. As soon as the dough is properly baked into bread, a product with superior quality and sensory features occurs. Fresh bread usually presents an appealing brownish and crunchy crust, a pleasant aroma, fine slicing characteristics, a soft and elastic crumb texture, and a moist mouthfeel (Giannou, Kessoglou, & Tzia, 2003).

1.2. Need of sensory evaluation and Role of fuzzy logic in sensory analysis

Sensory evaluation comprises a set of techniques for accurate measurement of human responses to foods and minimizes the potentially biasing effects of brand identity and other information

* Corresponding author.
E-mail address: a.mishra.fst@gmail.com (A. Mishra).

0023-6438/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.lwt.2012.03.026

influences on the consumer perception. Without appropriate sensory analysis, there is a high risk of market failure (Arazi & Kilcast, 2001) because comparison and choice are fundamental to consumers (Imm, Lee, & Lee, 2011). Fuzzy logic is an important tool by which vague and imprecise data can be analyzed and important conclusions regarding acceptance, rejection, ranking, strong and weak attributes of food can be drawn. In fuzzy modeling, linguistic variables (e.g., not satisfactory, good, excellent etc.) are used for developing relationship between independent (e.g., color, aroma, taste, mouthfeel, convenience etc) and dependent (e.g., acceptance, rejection, ranking, strong and weak attributes of food) variables (Das, 2005, pp. 383–402; Routray & Mishra, 2011). Fuzzy sets can be used for analysis of sensory data instead of average scores to compare the samples' attributes (Lincklaen et al., 1989), since fuzzy sets are not confined to a deterministic value and have a merit in sensory evaluation because human expressions on feeling for foods are fuzzy rather than deterministic. The developed fuzzy mathematical models perform remarkably well in the evaluation and ranking of food products (Uprit & Mishra, 2002). In fuzzy theory, a subject can be represented by fuzzy sets with a series of elements and their membership degrees compared to crisp sets without membership (Zimmermann, 1991). Such fuzzy sets provide the mathematical methods that can represent the uncertainty of humans' expression (Lazim & Suriami, 2009).

The objectives of this study were to optimize the flour composition of the breads on the basis of their dough rheological and textural properties viz., water absorption (g/100 g), dough development time (min), dough stability time (min), dough weakening (BU), dough extensibility (mm) and resistant to extension (kg); to prepare bread samples from the optimized composite flours and wheat flour; and to conduct a sensory analysis using fuzzy logic in order to analyze the acceptability of these breads.

2. Materials and methods

2.1. Procurement of raw material

Barnyard-millet (*Echinochloa frumentacea* Cv *VL-172*) grains were obtained from the experimental farm of Vivekananda Institute of Hill Agriculture (ICAR), Almora, Uttarakhand, India (Singh, Mishra, & Saha, 2010b; Singh, Mishra, & Saha, 2011a). The wheat (*Triticum aestivum*, Cv *VL-829*), proso-millet (*Panicum miliaceum*, local variety) and finger-millet (*Eleusine coracana* Cv *VL Mandua-149*) varieties were obtained from local market of Kharagpur, India (Singh, Mishra, & Saha, 2010a).

2.2. Formulation of millet-wheat composite flours

Millet-based composite flours viz., composite flour with barnyard-millet and wheat flours (BWCF, S1) and composite flour with barnyard-millet, finger-millet, proso-millet and wheat flours (BFPWCF, S2) were formulated on the basis of their dough rheological and textural properties viz., water absorption (maximum), dough development time (in range), dough stability time (maximum), dough weakening (minimum), dough extensibility (maximum) and resistant to extension (maximum). Two types of composite flours were made by blending of different millets flours in wheat flour. The composite flour BWCF was made using wheat, barnyard-millet flour and gluten whereas the BFPWCF was formulated using wheat, finger-millet, proso-millet and barnyard-millet flours.

2.3. Preparation of bread from the developed composite flours and wheat flour

For preparation of bread from composite flours, optimum straight dough bread making technique (AACC, 1995) was used. The bread dough was prepared from optimized ratios of composite flour/wheat flour, water (120 g/100 g composite flour) and other estimated ingredients like salt (1.75 g/100 g composite flour), dried baker's yeast (2 g/100 g composite flour) and sugar (6 g/100 g composite flour). The bread was baked in a preheated oven at 180 °C for 20 min. The prepared bread slices have been shown in Fig. 1.

2.4. Extensibility, firmness and bread color

Bread dough and loaves were analyzed for their extensibility and firmness using Texture Analyzer (Stable Micro System, UK). The extensibility test was performed using following texture analyzer settings: mode: measured force in tension; option: return to start; pre–test speed: 2 mm s^{-1}; test speed: 3.3 mm s^{-1}; post test speed: 10 mm s^{-1}; data acquisition rate: 200 pps. After 20 min resting the dough was placed in Kieffer rig and stretched. The same procedure was repeated for three times, following the AACC approved methods (AACC, 2000). For measuring the bread firmness cylindrical probe of 20 mm diameter was used. The color of bread crumb was measured by Konica Minolta Chroma meter.

2.5. Sensory evaluation of bread samples

After obtaining agreement about the characteristics of good quality bread and the meaning of different terminologies used in the sensory evaluation, a panel of 102 judges selected from among the staff members and students of Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur was selected. Judges were trained by discussing the definition of quality attributes selected for sensory evaluation, explaining the score sheet and method of scoring. They were advised to rinse their mouth with water between tasting the consecutive samples (Jaya & Das, 2003). Judges were instructed to give tick (✓) mark in the

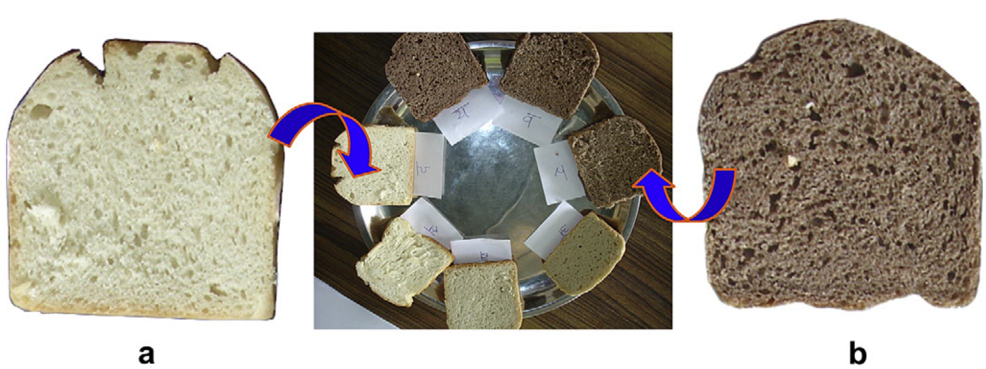

Fig. 1. Bread slices prepared from (a) Composite flour BWCF (b) Composite flour BFPWCF.