Application of Fuzzy Logic for Process Optimization in Traditional Food Preparation

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Abstract
Conventional control systems find it difficult to determine and control food process features such as multivariable, time-varying and non-linear; this can be resolved by fuzzy logic. The main problematic factor of making any Indian traditional food item is that of standardization. This study focusses on the various variables that strongly affect the quality of making the traditional food item. We have taken the example of traditional food item called Puran-Poli. This study also focusses on the quality of Puran-Poli which is made from various items like Puran which is a mixture of Harabara dal also called chickpea and jaggery powder. These products are used as stuffing inside the round and flat circular item called Poli which is sometimes called Paratha. This study is also aimed to propose a possible optimization or standardization technique of production through fuzzy logic.
Keywords: Fuzzy Logic, Puran, Puran-Poli, Sensory Evaluation

Introduction

India is a large country of various rituals and traditions and hence there are various food items prepared all over India depending on each region and its tradition. Puran Poli is an Indian traditional food which is very native to Maharashtra and various other states. It has different names like Puran-Pli or Vedmi in Gujarat, Boli in Tamil Nadu, Bobbatlu or Bakshalu in Andhra Pradesh, Holige and Obbattu in Karnataka.

This food is eaten during various festivals across different states including Maharashtra. This dessert is made up of harbara dal, jaggery, wheat flour and various other nutritious contents. Fuzzy logic solves the inaccurate information issues related to precision. Fuzzy logic is mostly used in situations where opinion plays an important role. Fuzzy logic is used so that all the complicated mathematical equations are based on understanding of human perception where decision is difficult to make.

Fuzzy systems can use figures instead of words for explaining the relationship between predictive and target variable. It also consists of in-built formulas for calculating the responses of physical evaluation of food

material which gives the idea about the quality of food item made. There exist different recipes of Puran Poli across states.

So, to make the taste unique everywhere there is a need for consistency of recipe and various parameters in preparation of puran. The objective of this study is to improve the recipe by sensory analysis using fuzzy logic.

Literature Review

Puran Poli is a traditional dessert which is specially prepared on festivals. Puran Poli is prepared using various recipes which differ according to region. The various ingredients are used for the preparation of Puran-Poli such as Bengal gram, sugar and jaggery as a major ingredient, and cardamom, nutmeg, fennel as a minor ingredient.

The ingredients which are used in the preparation of Puran-Poli contain high nutritional value. The various advanced technologies are also used during study of Puran-Poli such as radio frequency heating technology or radio frequency dehydration methods, thermal processing, frozen methods etc.

In this paper we present detailed information about Puran-Poli which includes the methods and ingredients used in preparation of Puran Poli, regional variation, nutritional value and health benefits.

1. Intelligent Food Processing and Fuzzy Modeling

Due to its ability to manage linguistic parameters and uncertainty, fuzzy logic is increasingly being used in food systems, according to recent studies. Fuzzy controllers greatly increased prediction accuracy for nonlinear food processes, as Kumar and Patel (2020) showed. Their research demonstrates that fuzzy logic-based models outperform traditional algorithms in simulating human decision-making [6].

2. Fuzzy Logic in Heat and Moisture Control for Traditional Foods

The main problem with traditional cooking is heat transfer and moisture control. Singh and Banerjee (2020) implemented fuzzy temperature controllers during the production of Indian flatbread, which improved the uniformity in its texture. According to their results, fuzzy inference systems capture the knowledge of artisanal cooking and transform it into programmable rules [7].

3. Optimizing Products made from Pulses and Cereals

Similar to filled chickpea preparations, pulse-based preparations are intricate systems with fluctuating thermal and hydration behaviors. Fuzzy optimization was used by Rahman et al. (2021) to improve texture and sweetness consistency in pulse-based formulations. These findings are highly relevant to the standardization of puran (chickpea—jaggery) [8].

4. Fuzzy Sensory Evaluation in Food Quality Assessment

Fuzzy logic is now widely used in the modeling of subjective human judgments in various artificial sensory systems. Chatterjee and Mehta (2021) reported that the assessments by fuzzy sensory models were almost identical to those generated by a trained human panel. Based on the results, these models are proposed to reduce subjectivity in conventional food quality grading [9].

5. Data-driven Fuzzy Systems for Standardization of Traditional Food

Traditional foods usually have high batch-to-batch variability. According to a study by Iyer and Kulkarni (2022), a hybrid fuzzy-expert system standardized dough consistency and cooking stages for Indian parathas. Their approach supports scalable production without compromising cultural authenticity [10].

6. Fuzzy Logic in Process Automation for Ethnic Foods

For ethnic and handcrafted foods, the food industry is gradually moving toward automated systems. For layered Indian candies, Das and Srinivasan (2022) suggested a fuzzy automation framework. They showed improved control over texture and caramelization. This study demonstrated how fuzzy logic can be used to commercialize traditional recipes [11].

7. Fuzzy Multi-criteria Models for Ingredient Ratio Optimization

Ingredient proportions in traditional foods require careful balancing to maintain taste and structural integrity. Mandal and Shah (2023) described how fuzzy multi-criteria decision systems effectively optimized the ingredient ratios of multi-component foods. This approach applies to Puran Poli, where dough and stuffing variables interact with each other [12].

8. Fuzzy Process Control under Variable Environmental Conditions

Such environmental fluctuations as humidity and temperature impact food texture and dough elasticity. Bhosale et al. (2023) developed a fuzzy controller that adapted real-time cooking parameters in order to compensate for these climatic variations. The results of this work are important for traditional foods prepared in uncontrolled kitchen environments [13].

9. Soft Computing for Texture Prediction in Indian Flatbreads

The nonlinear behavior of dough-based products makes texture prediction challenging. In order to predict the softness and browning levels of chapatis, Rao and Jadhav's (2024) study combined machine learning and fuzzy logic. Their hybrid model's high accuracy portends the development of intelligent cooking systems in the future [14].

10. Fuzzy-rule-based Modeling for Sweet Fillings and Thermal Stages

Jaggery mixes and other sweet fillings have extremely sensitive thermal transitions that depend on moisture content and heating rate. A fuzzy-rule-based model was created by Patil and Deshmukh (2025) to identify the ideal heating times for jaggery candies. Their findings indicate that Puran Poli has significant application potential for Puran preparation [15].

Proposed Methodology

In India preparation of traditional food is a quite prestigious task. It requires proper combination of various items and in proper sequence and at proper time. In this paper we concentrate on making of a traditional food item called puran.

The study of this paper aims to use fuzzy logic in making this traditional food item by using sensory analysis and various methods so that there can be uniqueness in the preparation of the traditional food item Puran-Poli.

Across studies from 2020–2025, fuzzy logic has been widely validated for food processing, sensory evaluation, ingredient mixing, and traditional food automation.

Key Missing Related to Puran Poli

- No integrated fuzzy model that combines the heating stages, stuffing consistency, and dough softness.
- Few studies have been conducted on traditional multi-component foods that have both solid and semi-solid phases.
- Most research isolates individual steps, but Puran Poli requires end-to-end process control.
- No research specifically addresses standardization of Indian festive foods like Puran Poli.

Thus, the study fills a clear research gap by proposing a fuzzy logic–based standardization model for Puran Poli preparation.

Methodology

The preparation process began by cleaning the harbara dal thoroughly and soaking it in room-temperature water for approximately three hours to allow maximum moisture absorption. After soaking, the dal was cooked for 10–12 minutes until it reached an optimal softness suitable for further processing. This initial preparation was crucial for maintaining uniformity in the recipe and for effective control of puran-related parameters.

To study the effect of ingredient ratio and grinding time, four levels of cooked harbara dal to jaggery were considered: 1.0, 2.0, 3.0 and 3.5. Besides, four grinding time levels such as 3 minutes, 4 minutes, 4.5 minutes, and 5 minutes were used systematically for the mixtures. After grinding, each mixture was heated for 5–6 min and heating was stopped once the puran started to show its typical golden-brown colour.

To guarantee a consistent texture throughout the batch, the partially cooked mixture was then turned into a smooth paste and run through a fine strainer. The consistency, texture, color, and general quality of each prepared sample were meticulously recorded for analysis.

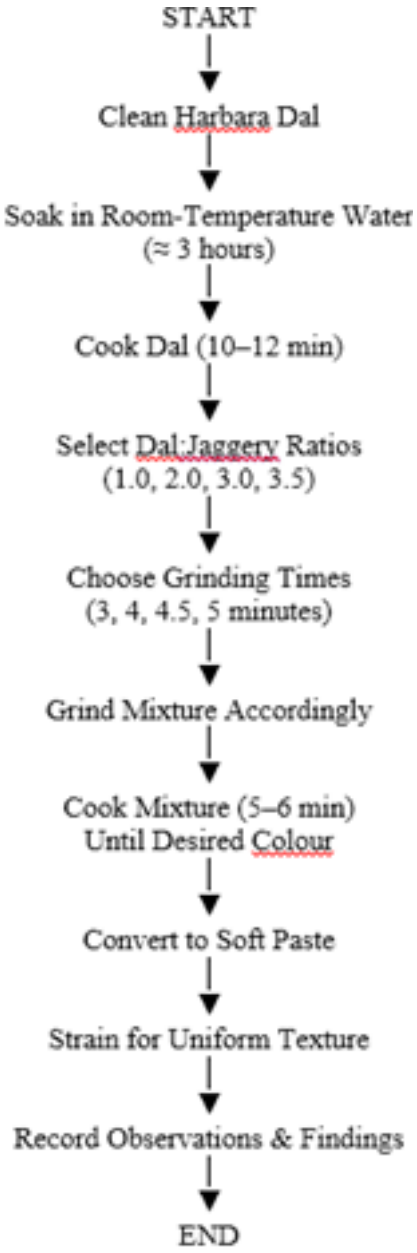

Figure 1 Flowchart of Methodology

Results

Following table displays the sum of proper scores of attributes for making the good quality of puran sample.

Table 1 Sensory Factors According to Numerical Values

Samples	Sensory factors according to numerical values				
	Bad	Satisfactory	Medium	Good	Excellent
Color					
C1	0	2	12	15	4
C2	1	3	10	10	6
C3	2	3	15	16	5
C4	1	6	11	17	6
C5	0	4	13	18	4
Flavor					
F1	2	6	10	14	1
F2	1	8	16	17	5
F3	0	9	11	10	4
F4	4	10	15	13	2
F5	0	4	12	13	5
Smoothness					
S1	0	4	10	13	5
S2	1	9	8	14	1
S3	0	5	11	16	4
S4	1	6	12	13	5
S5	0	7	14	14	2
Acceptability					
A1	2	4	13	15	2
A2	1	9	10	9	4
A3	0	6	12	12	4
A4	3	3	14	4	3
A5	4	4	11	11	4

This table shows the sum of sensory scores of quality attributes of puran sample in general with sensory score.

Table 2 Sensory Scale Factors on 5-point Scale

Sensory quality attributes of puran	Sensory scale factors on 5-point scale				
	Bad	Satisfactory	Medium	Good	Excellent
Color	0	3	16	9	18
Flavor	0	2	10	15	17
Smoothness	0	1	7	8	16
Acceptability	0	2	5	7	20

Conclusion

Puran samples were prepared using varying ratios of harbara dal and jaggery in combination with different grinding times, and their physical characteristics were evaluated using a five-point rating scale.

The collected data were further analyzed through a fuzzy logic–based approach to interpret the sensory and physical variations among the samples. Based on the fuzzy evaluation outputs, one particular puran formulation demonstrated superior overall acceptability compared to the others. This indicates that the use of fuzzy logic can effectively support the standardization and optimization of traditional food preparations such as puran.

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