Soft Computing applications in predicting Palatability Preferences in Rice Varieties

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***Abstract*— Rice is the only cereal consumed as staple food mainly as whole grains by more than 50 percent people of the world. The overall cooking and eating quality of such a significant crop determines its widespread preference, acceptance and consumption. The varieties, hybrids, landraces of rice are immense in diversity not only in morphological traits but also in end-use qualities. Hence, the choice for palatability relies on many cooking and eating quality parameters such as grain shape, chalkiness, gelatinization temperature, gel consistency, amylose content etc., Based on the combinational composition of these parameters, all the known varieties of rice have been classified, identified and promoted. For such quality classification, soft computing technique –fuzzy logic has been employed supported with correlation studies as the criteria for determining the cooking and eating quality preference includes both discrete and non discrete parameters. The output results in sorting 11 varieties into 5 preferential groups based on combination of 6 palatability parameters.**

***Keywords*—cooking and eating quality, soft computing, fuzzy logic, rice varieties, palatability**

I. INTRODUCTION

It is obvious that consumption preference for any food commodity depends on the cooking and eating quality parameters. The cereal monocot whole grain of rice is the main staple food for majority of Asian and West Indies population. There are diverse varieties identified and differentiated based on culinary preferences. For instance, in India, non sticky varieties of rice are preferred whereas, in Far East countries stickiness of cooked rice grains is the preferred attributes. These criteria of likes and dislikes on cooking and eating quality of rice grains promotes some varieties and some are dispelled from consumer market owing to lack of preferential palatability parameters in such varieties.

The physico-chemical parameters determining these cooking and quality preference classifications in rice grains have been analysed and estimated by dieticians and scientists all over the world. The experimental and experience based evidences indicate the attributes of palatability as amylose content (Juliano 1985; Unnevehr et al. 1992), gel consistency (Cagampang et al. 1973) and gelatinization temperature (Little et al. 1958). Apart from these parameters, grain shape and chalkiness also play a vital role in defining the palatability classification.(Danbaba et al 2011).

Specifically in Tamil Nadu of South India, hundreds of traditional rice varieties had been in vogue clearly earmarked with nutrient values and culinary taste. The ancient Tamils have adopted the art of naming such varieties of rice based on the palatability parameters itself – Neikitchadi (Ghee like taste), Thuyya malli (Cooked grains look like full bloom flowers of Jasmine) etc. Understanding the combination of these attributes in determining the ultimate palatability preference needs to be ventured based on balanced analysis taking into account the characters such as appearance, taste, nutrition, cooking time etc., Realising the significance of consumer preference of such traditional rice varieties could aid in the conservation and propagation of such varieties using conventional and unconventional breeding programmes.

II. FUZZY LOGIC

The theoretical developments and advances in soft computing have created advanced softcomputing techniques like Fuzzy logic (FL), Artificial Neural Networks(ANN), Genetic Algorithms(GA) etc. Fuzzy find its applications in reasonable human like decision making in sectors which involves a certain degree of uncertainty or vagueness. Agricultural sector has many such indecisive and unpredictable zones which offer potential application ground for soft computing skills such as Fuzzy logic. According to Yanbo Huang et al. (2010), based on a summary of literature survey for 136 fuzzy related reports, about 14% of research outputs in food quality and safety decision mechanisms are based on fuzzy logic analysis.The fuzzification and defuzzification

is a crossing point between logic and reasoning. Thus, FL mimics human decision management. An FL system has wide range of applications including morphological change detection in environmental components, forecasting wheat production, etc. (Javaheri 2008; Narendra Kumar *et al* 2010).

The aim of this soft computing application at present is to develop a palatability index for the South Indian traditional rice varieties. A database for the palatability parameters such as amylose content, amount of protein, Gelatinization temperature (GT) range, and Chalkiness index is estimated and are employed as membership function in a fuzzy model. Fuzzy Analysis (FA) is set up to calculate palatability suitability index to identify varieties of high consumer preference for cultivation and conservation of such traditional varieties of rice. Promotion of consumer preferred varieties could boost up market value and thereby increasing the remuneration to the marginal and small farmers of Tamil Nadu.

III. MATERIALS AND METHODS

The basic five parameters for cooking and eating quality such as amylose content, amount of protein, gel consistency, gelatinization temperature chalkiness and grain shape are estimated for 11 traditional varieties of rice. The traditional varieties are procured from local village level seed banks, traditional farming practicing farmers and NGOs. The physico chemical analysis for the above listed parameters are done using the procedures of Cagampang *et al*. (1973) for gel consistency, Little *et al*. (1958) for GT, Juliano (1971) for amylose content, AOAC (1962) for protein content and finally shape of the grains are determined using quality evaluation procedures of IRRI (2002) .

A. Names of traditional rice varieties and standard for comparison

Mapillai samba, Gundu nel, Madumuzhungi, Samba mosanam, Vadan samba, Kitchilli samba , Pisini, Thuyya malli, Kulla kar and Super ponni have been collected. Based on the amylose content, the gelatinization temperature varies and the tenderness of rice grains depends upon the amylose content (Juliano, 1985). Starch is made of amylose and amylopectin chains. Of these, the amylose has a strong correlation with gel consistency and grain shape. The protein content adds to the nutritious quality of the variety. Hence all these interdependent variables have been designated as membership functions in the fuzzy model of present analysis.

IV. FUZZY MODEL

A fuzzy model for predicting palatability preferences was set up using 6 parameters, which were fuzzified by 3 or 4 types of fuzzy sets, which were fuzzified based on the classifying criteria as applicable for each factor of the fuzzy set. Inference block was based on association rules of each membership function on the output decision for the palatability preferences. Defuzzification using height method has resulted in arriving at the palatability preference indices. Computer language based programming was employed for executing this fuzzy model

A. *Fuzzy inputs*

- Milled grain shape - <2.0, 2.1-3.0 , >3.0
- Chalkiness score - 0,1,5,9
- Gelatinization temperature score - 1,2,3,4
- Gel consistency -41mm, 41-60mm, >60mm
- Amylose content - <20%, 20-25%, >25%
- Proetin content - <7%, 7-9%, >9%

B. MEMBERSHIP FUNCTIONS

1) Milled grain shape

<2 - Slender

2.1 – 3.0 - Medium

>3 - Bold

2) *Chalkiness score*

0 0%None

1 - Less than 10%

5 - 10-20%

9 - >20%

3) Gelatinization temperature score

1 - Low Gel T

2 - Intermediate Gel T
3 - High Intermediate Gel T
4 - High Gel T

4) Gel consistency
41mm- Hard gel
41-60mm- Medium gel
>60mm - Soft gel
5) Amylose content
20-25% - Intermediate
>25%- High
<20%- Low
6) Protein content
7% - Low
7-9%- Intermediate
>9% - High
C. Out put fuzzy sets

All together 6 parameters – Grain shape, Gelatinization Temperature, Gel consistency, Amylose content, Chalkiness score, Protein content have been recorded for each of the 10 traditional varieties. But Grain shape, Gelatinization temperature, Gel consistency, Amylose content and Chalkiness are considered as key factors in deciding the palatability preference class based on taste and appearance. Whereas, protein content is also included in deciding if palatability is to be decided based on nutritional grounds. Based on the association of these factors and their significance of contribution in determining the cooking and eating quality of rice grains, five classes of palatability preference is arrived as given below.

Lowest Palatability
Low Palatability
Intermediate Palatability
High Palatability
Highest Palatability

Thus Palatability was classified for each of the 10 rice varieties as presented in the Table 1 below based on the membership functions assigned to the input factors as presented in Fig.1 to Fig.5

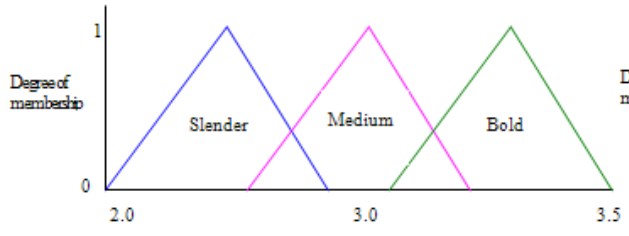


Fig.1- Milled grain shape

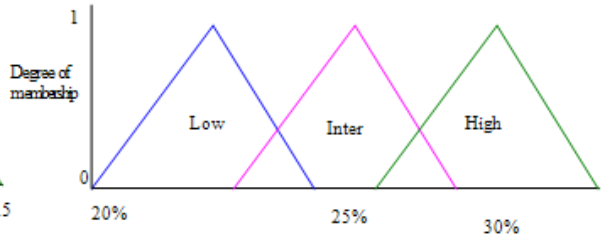


Fig. 2-Amylose

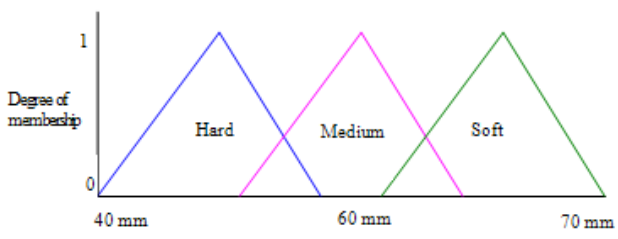


Fig.3 Gel consistency

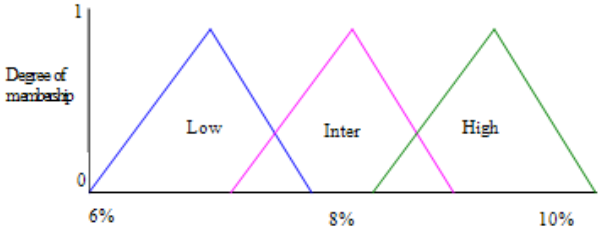


Fig. 4- Protein content

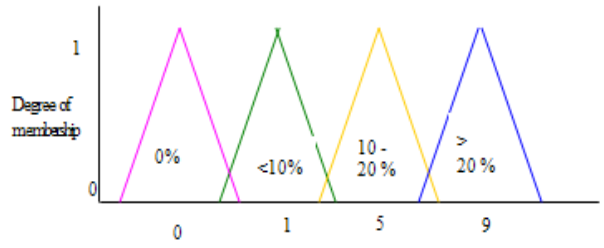


Fig 5-Chalkiness score

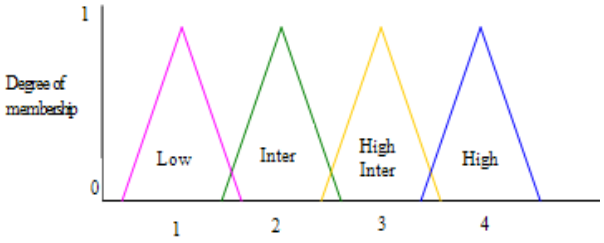


Fig 6- Gelatinization temperature class

V. Correlation Studies

Correlation studies are also undertaken to understand the magnitude and direction of association of each of the palatability parameter viz., grain shape, chalkiness, gelatinization temperature, gel consistency, amylose content and protein content with each other. Correlation analysis has been carried out using Graph Pad Prism 5. This analysis could enable us to clearly understand about the prime parameters which are highly correlated with each other and the variables/factors which are least correlated with each other. This has enabled us to understand the justification of the rules framed for deciding the palatability preference index in fuzzy logic.

VI. Results and Discussion

A. *Fuzzy Logic*

Table 2. Palatability Preference Index Classification

I-Intermediate; HI –High Intermediate; L-Low; H-High

Variety of Rice	Grain shape	Gel Temp Class	Amylose content (%)	Gel consistency (mm)	Chalkiness score	Protein content (%)	Palatability Index
Mapillai samba	Bold	HI	I	Soft	10-20%	Intermediate	**Low**
Gundu nel	Bold	HI	H	Soft	10-20%	High	**Intermediate**
Madu muzhungi	Bold	HI	H	Soft	>20%	Low	**Low**
Samba mosanam	Bold Slender	HI	H	Soft	10-20%	Intermediate	**Intermediate**
Vadan samba	Bold	HI	I	Soft	>20%	High	**Lowest**
Kitchilli samba	Slender	L	H	Soft	<10%	Intermediate	**High**
Pisini	Bold	HI	H	Soft	>20%	Intermediate	**Intermediate**
Thuyyamalli	Slender	L	H	Soft	0%	High	**Highest**
Kulla Kar	Bold	HI	H	Soft	10-20%	Intermediate	**Intermediate**
Super ponni	Slender	L	H	Medium	<10%	Intermediate	**High**

The palatability preference classification was carried out based on the assigned membership functions respective to the crisp values of cooking and eating quality factors which mainly determine taste, appearance, tenderness etc. The soft computing techniques employed thus enabled to identify rating for preferred rice variety with respect to palatability. For example, as in the case of Thuyyamalli, "IF the grain shape is 'Slender' AND Gelatinization temperature is 'Low' AND Gel consistency is 'Soft' AND Amylose content is 'High' AND Chalkiness is '0%' AND Protein content is 'High' THEN the Palatability class is 'Highest' " for Thuyyamalli.

Analogous to the above mentioned fuzzy rule, defuzzification is done based on 1295 similar fuzzy rules coined using the soft computing technique to classify the varieties with Lowest / Low / Intermediate / High / Highest palatability preference index for 10 traditional rice varieties. A sample table to illustrate such fuzzy rules is presented in Table1. Reliable output classifying the rice varieties based on consumer preference for palatability is arrived. The above table depicts the palatability preference index for the 10 varieties involved in the present study.

According to Juliano (1971), the rice varieties with high amylose content tend to be dry, hard and less tender after cooking and their relative expansion in volume is high and display high degree of flakiness. Owing to these properties, people in Japan, South Korea prefer rice varieties with low amylose content whereas, the varieties of India, Indonesia, Malaysia. Thailand, Vietnam and Philippines are observed to have intermediate to High amylose content in line with the observation made in the present study. Indians prefer varieties with intermediate preference rather than high amylose varieties. It has been observed and claimed that intermediate amylose varieties of rice are much preferred in South and Southeast Asian countries (Md. Sarowar, 2009).

Another significant parameter that determines palatability preference is gel consistency which is based on amylose content. Perez and Juliano (1977) had noted that out of the 11 milled rice varieties, most of the intermediate amylose rices with good eating quality have soft gel consistency. Hence, in the present analysis using FL, 'softness' has been assigned as preferential membership function. Chalkiness is undesirable virtually in all instances. It detracts from overall appearance, uniformity and generally results in lower mill yields because chalky grains tend to be weak and break easily. Hence, palatability index has been defined giving preference to 0% chalkiness and the varieties with >20% chalkiness is least preferred.

With respect to grain shape, preference for size and shape o grains differs among varied group of consumers. Some prefer short bold grains; some others have a preference for medium long grains and long slender grains (like Thuyyamalli) and are highly prized. But, as far as Indian subcontinent is considered, slender type grains are much preferred.

Gelatinization temperature (GT) is a major determinant of cooking quality of rice varieties. It is the indicator of time required for cooking. As the process of cooking starts, the starch granules begin to swell as the temperature of water increases. Hence, GT ranges as Low as (55-69°C) and as high as (70-74°C), the high intermediate and intermediate ranges fall in between these two extremes. If, the varieties have high GT, then the cooking time and water requirement will be on the high side. Hence varieties with Low GT are considered to have best cooking quality. With respect to protein content, it doesn't have a direct role in determining the palatability parameter. But, in nutrition point of view, rice varieties with high protein content are preferred.

On the whole, it could be concluded that majority of Indian consumers prefer slender, non waxy, with translucent kernels, high-intermediate levels of amylose that remain soft after cooking and with high protein content. Based on these non-discrete but overlapping features that are inherently present in thousands of natural and artificial varieties of rice, application of fuzzy logic in deriving more than thousand association rules has rendered the analysis in determining the palatability index precise and time saving with respect to each variety under study.

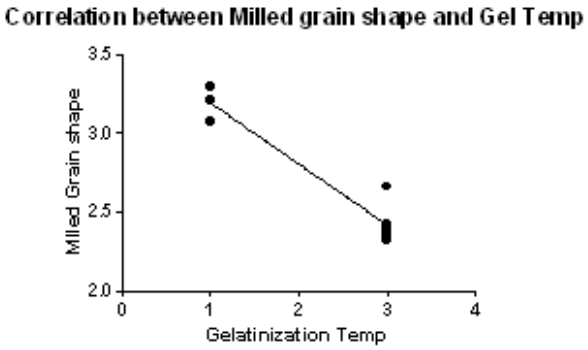
B. Correlation studies

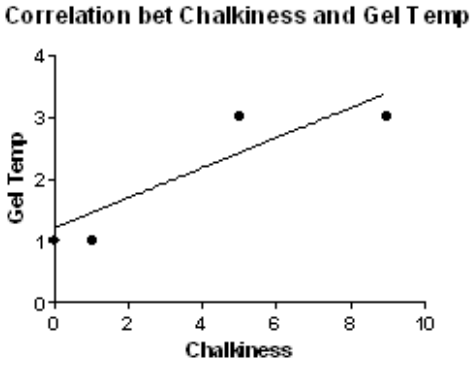
TABLE 3. CORRELATION AMONG THE PALATABILITY DETERMINING FACTORS

Character	**Milled Grain Shape**	**Chalkiness**	**Gelatinization Temp**	**Gel Consistency**	**Amylose content %**	**Protein content %**
Milled Grain Shape	**1**	-0.880	-0.962	-0.674	-0.197	0.033
Chalkiness		**1**	0.856	0.558	0.189	-0.156
Gelatinization Temp			**1**	0.563	0.176	-0.081
Gel Consistency				**1**	0.047	0.116
Amylose content %					**1**	-0.683
Protein content %						**1**

From the above table, it could be vividly inferred that milled grain shape is positively correlated only with protein content and is with the highest negative correlation with Gelatinization temperature (Fig.7). Whereas, Chalkiness is negatively correlated with protein content alone and has the maximum positive correlation with gelatinization temperature (Fig.8). Gelatinization temperature is significantly positively correlated with gel consistency but non-significantly correlated with amylose content and negatively correlated with protein content. Gel consistency and Amylose content correlates negatively with milled grain shape and positively correlates

with all other parameters non- significantly. Protein content correlates negatively with all other parameters except for Gel consistency and milled grain shape. These correlation logics helps us to outline that if amylose content and gel consistency are favoured as positive for palatability preference, then milled grain shape, chalkiness and gelatinization temperature are designated as negative for palatability preference indexing.





VII. CONCLUSION

The application of Fuzzy logic in determining the palatability preference index has evolved a overall combinatorial index chart to identify the palatability index for any given variety provided with the estimated values of factors of cooking and eating quality. In the present study, only 6 parameters have been included and if more factors such as water uptake, volume expansion ratio and elongation ratio can also be taken into account to obtain the precision in determining the palatability index to be appreciably high. Moreover, the association rules have been framed based upon Indian likes and dislikes in palatability, but this soft computing skill could be extended to determine palatability preference index for many other varieties available elsewhere depending upon their regional preferences and reservations in deciding the palatability preference index globally.

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