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Research Article

Sensory evaluation and consumer acceptability of zinc biofortified rice by farm women in Telangana, India

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Abstract

Most of the Indian diets are typically based on cereals and lack micronutrient-rich vegetables, fruits, and flesh foods. The incorporation of zinc biofortified rice in daily diets can help overcome zinc deficiency. The present study aimed to analyze the consumers' acceptance of zinc biofortified rice as the willingness of consumers to accept it is important for the success of biofortification strategy to combat micronutrient malnutrition. The consumers' acceptance of zinc biofortified rice in terms of its hand feel mouth feel texture, taste, and overall acceptability was determined using the Five-point Hedonic scale. Hand-pounded samples of zinc biofortified rice and control were provided to sixty farm women to evaluate by the Home Use Test protocol. The index of acceptability (IA) was worked out for the acceptance of zinc biofortified rice and was found to be greater than 70% for all the parameters. The consumers' socio-economic characteristics did not show a significant relationship with the acceptability of zinc biofortified rice except for hand feel texture. Based on the hedonic categorization suggested by Belmes (2019), the overall acceptability of both the zinc biofortified rice and control are in the acceptable category of hedonic rating. Therefore it can be concluded that the zinc biofortified rice variety DRR Dhan 45 is equally acceptable to the consumers as the control rice. The consumers' socio-economic characteristics did not show a significant relationship with the acceptability of zinc biofortified rice. The zinc biofortified rice can be promoted for use in daily diets to help meet the zinc needs of the family and included in the nutrition intervention programs of the country for overcoming micronutrient malnutrition.

Keywords: Consumer acceptability, sensory evaluation, zinc biofortified rice, malnutrition, farm women

1. Introduction

The micronutrients are very important for various physiological functions and their deficiencies do not lead to physical manifestations as those of macronutrients. Of these micronutrients, deficiencies of zinc and iron are reported to be the most widespread, and their adverse health consequences more severe, , mostly in low and middle-income countries(Gupta *et al.*, 2020). In India, iron and zinc deficiency among children is high (NFHS-4, 2017; and Matthew *et al.*, 2019). Although, zinc and iron both are important micronutrients but this article is focusing on zinc only.

The micronutrient zinc plays an important role in the normal functioning of the body and is integral part of enzyme systems. Mnay important biological functions of zinc include, gene expression, cell division and immunity. (Brown *et al.*, 2004). Adequate dietary intake of zinc helps in normal linear growth of children and has an ameliorating effect on the skin.(Hess and King,

2009). Zinc deficiency in pregnant women may lead to complications during pregnancy. (Kohn *et al.*, 2000; Donangelo and King, 2012).Zinc palys an important role in linear growth and weight gain (Brown *et al.*, 2002). Zinc deficiency in mothers leads to low supply of zinc to the fetus resulting in premature and low birth weight babies (Hess and King, 2009). the most common feature of zinc deficiency may manifest as diarrhea, respiratory infections, impaired immunity and short staure. (WHO, 2002; Ezzati *et al.*, 2002).

A cross-sectional study in India has reported poor cognitive performance of 45% of the adolescent girls due to low plasma concentration of zincsignifying the need to incorporate zinc rich foods in the diets.(Kawade 2012). A high prevalence of zinc deficiency due to low dietary intake has been reported in (64.6%) in pregnant women and 42% in among the nulliparous non-pregnant women in India (Pathak *et al.*, 2008; Pathak *et al.*, 2003). The inadequacy of zinc intake in India is very high and devising an intervention program targeting vulnerable populations is essential (Smith *et al.*, 2019).

Inadequate intake of iron and zinc is one of the most significant determinants for the development of their deficiency (de Benoist *et al.*, 2007). Rice is the staple food but in comparison to other foods, it is poor in iron and zinc content (Hemalatha *et al.*, 2007). Elevated zinc requirement, poor absorption and utilization by the body and increased losses, are some of the common factors resulting in zinc deficiency. Dietary factors play an important role in the development of zinc deficiency in developing countries (Gibson and Anderson, 2009). The high phytic acid content in the cereals and cereal-based diets affects their absorption due the formation of zinc-phytic acid complexes in the intestine (Lonnerdal 2000, Davidsson *et al.*, 2004 and Egli *et al.*, 2004). The bioavailability of zinc is greatly influenced by the presence of several other inhibitors (Davidsson *et al.*, 2004), including calcium and polyphenols (Kim *et al.*, 2011). Unlike iron deficiency, due to the non-specific clinical features the diagnosis of zinc deficiency is difficult and the low level of circulating zinc may be used as an indicator.

The recommended dietary allowances for zinc (mg/d) computed by ICMR are: adult men 12 mg/d, adult women10 mg/d, pregnant women 12 mg/d, lactating women 12 mg/d, boys aged 13-15 yr 11 mg/d, girls 13-15 yr 11 mg/d, and children 7-9 yr 8 mg/d (NIN, 2009).The zinc requirements are high during pregnancy and rapid physiological growth as in children and the inadequate intake leads to higher deficiency.

The pharmaceutical approach of supplementation, the industrial approach of food fortification, and agricultural approaches of dietary diversification and bio-fortification have been advocated as some of the strategies to address micronutrient deficiencies. Crop bio-fortification is increasingly being recognized as a cost-effective and sustainable approach.

Rice is a major staple food consumed widely by the poor population and serves as an ideal crop for fortification. Rice consumption in India was estimated to be 102 million tonnes in 2019-20 and it is expected to increase to 108 million tonnes in 2020-21 (Reidy 2020). Therefore, in the bio-fortification program (Nestel *et al.*, 2006; Pfeiffer & McClafferty, 2007), a major focus is to breed rice containing more Zn. In this direction, the Indian Institute of Rice Research, Hyderabad, has made considerable efforts and developed three bio-fortified high zinc rice varieties, namely, DRR Dhan 45, DRR Dhan 48 and DRR Dhan 49 with a zinc concentration of 22.6 ppm, 24 ppm, and 25.2 ppm respectively in polished grain and all are of medium duration (125-130 days) with an average grain yield of 50q/ha (Yadava et al., 2020). Some more varieties like Zinco Rice, CR Dhan 311, and CR Dhan 315 have been developed and released by other research institutes (Yadava *et al.,* 2020).

Including biofortified varieties in daily diets may help to overcome zinc deficiencies in vulnerable populations *viz.*, women and children (Woods *et al.*, 2020). The nutritional intervention program of the Indian Government, Poshan Abhiyan (India.gov.in) can benefit from the biofortified crops in its efforts to reduce undernutrition and stunting as demonstrated in other regions of the world as a simple and cost-effective strategy (Reddy, 2020).

The willingness of consumers and producers to accept new crop varieties will determine whether biofortification can be successfully implemented. The acceptance of biofortified varieties by consumers is an important aspect of the biofortification program (Saltzman *et al.*, 2013). Consumer acceptance of new products is evaluated primarily by three methods, viz. laboratory tests, central location tests (CLT) and home use tests (HUT) (Meilgaard

et al., 2007). In HUT, the consumer prepares the food in his/her own way and consumes the food in its own environment. In-home use test the consumers can assess the product as per their expectations (Lawless and Heymann, 2010).

The objective of the present study was to determine consumers' acceptance of zinc biofortified rice variety DRR Dhan 45 through sensory evaluation in home-use testing. The rice variety DRR Dhan 45 is developed by the Indian Institute of Rice Research (IIRR) and released in 2016. It is the first among the high zinc rice varieties notified at the national level and has an overall mean zinc content of 22.6 ppm (Yadav *et al.*, 2020). This is a semi-dwarf, medium duration (125 days) variety with long slender grain and non-lodging type. It is moderately resistant to blast, sheath rot, and rice tungro virus. It is released for the states of Tamil Nadu, Andhra Pradesh, and Karnataka and has good cooking quality with desirable amylose content (20.7%).

2. Materials & Methods

The study was conducted in Nalgonda district of Telangana State, India, which has a high prevalence of stunting (28.3%), underweight (31.3%), wasting (21.2%) and anemia (69.2%) among the child population (Kim *et al.*, 2019) and high levels of anemia among women, 56.2% (NFHS-4, 2017). Convenience sampling was used in the study and ten farm women beneficiaries of the outreach programs of the Indian Institute of Rice Research (IIRR) were selected randomly from each of the six tribal hamlets of Deverkonda Mandal of Nalgonda district of Telangana. Thus the total sample size was 60 farm women. An information session was conducted in the local language with the farm women to obtain their verbal consent. The farm women were provided 500 gm each of hand-pounded rice of the high zinc variety DRR DHAN 45 (Zinc, 22.6 ppm) and check variety (Zinc, 16.7 ppm) (Yadav *et al.*, 2020).

The cooking protocol for both biofortified and control variety was typical of how the rice is cooked by the farm women. The farm women rated the zinc biofortified rice and control with respect to hand feel texture, mouthfeel texture, taste, and overall acceptability. A hedonic test was used on a 5-point hedonic scale (1-very poor, 2-poor, 3- neither poor nor good, 4-good, and 5-very good). The intervals between each score are not the same and also a product that is rated 4 is not necessarily two times as much liked more than a product rated 2. The consumers' scores are measured on an ordered categorical scale and need to be analysed accordingly (Coe, 2002).

2.1 Sensory evaluation testing using modified home use testing (HUT)

Sensory characteristics of zinc biofortified rice (DRR Dhan 45) and control (BPT-5204) were determined using a home use test. At the time of the present study, only small quantity of paddy grain of zinc biofortified rice was available and it could not be commercially milled for consumer acceptability study. Therefore, for home use test, hand-pounded samples of both zinc biofortified and control rice were provided to 60 farm women which is the minimum number of consumers required for a consumer acceptability study (Hough *et al.*, 2006; ISO 8587:2006; and Stone and Sidel, 2004) and hedonic scaling test (Gacula and Rutenbeck, 2006).

The hedonic rating as suggested by Belmes (2019) on a five-point scale was used for the categorization of sensory attributes of both zinc biofortified rice and control. The associated ranges of scores with the level of acceptability were rated as follows: 4.50-5.00 as Highly Acceptable (HA); 3.50-4.49 as Acceptable (A); 2.50-3.49 as Moderately Acceptable (MA); 1.50-2.49 as Slightly Acceptable (SA) and 1.00-1.49 as Not Acceptable (NA). The independent Student's *t* test was used to test the difference in mean scores between the two types of rice**.**

2.2 Index of acceptability (IA)

The index of acceptability (IA) was calculated using the following equation (Fernandes and Salas-Mellado (2017):

IA (%) = (Score x100) / 5

Where, the score represented acceptability reported by the farm women based on the 5-point hedonic scale.

3. Results and Discussion

3.1 Socio-demographic characteristics of the consumers

The socio-demographic characteristics of the respondents indicated that , majority of the respondents (66.7%) belonged to 31-50 age group followed by the 21-30 years age (20%) and about 13% were in the 51-60 years age group. A very high percentage (75%) of the respondents were illiterate followed by 15 percent educated to the primary level schooling followed by nearly seven percent

educated up to the secondary level and only three percent belonged to the higher secondary education category. Most of the farm women (36.7%) were having 11-20 years of farming experience followed by 35% having 1-10 years, 23.3% of the respondents had 21-30 years experience and only a very small percentage (5%) had a farming experience in the range of 31- 40 years. It was recorded that 57 percent of the farm women were members of some organizations and 43 percent of them were not having membership in any organization.

3.2 Consumer acceptability of sensory characteristics of zinc biofortified rice and control

The mean sensory scores of zinc biofortified rice and control have been presented in Table 1. None of the farm women rated the hand feel texture as very poor or very good. An equal percentage (37%) of respondents rated it in the 'poor' and 'neither poor nor good' category. Only 25% of the consumers rated it as 'good'. The mouthfeel texture was rated as 'good' by 56.7 % of the farm women followed by 'neither poor nor good' by 30%. An equal percent of farm women (6.7%) rated it as 'poor' and 'very good'. The taste of biofortified cooked rice was rated as 'good' by 50% of the farm women and 30% rated it as 'very good' followed by 'poor'(20%) and 11.7% rated it as 'neither poor nor good' in taste. The overall acceptability of zinc biofortified rice was rated as 'good' by 56.6% of the consumers followed by 25% showing a neutral attitude of 'neither poor nor good', 13.3% rated it as 'very good' and 5% rated it as 'poor'.

Similarly, for control, none of the farm women rated the hand feel texture as 'very poor', but 5% rated it as 'poor'. About half of the respondents (51.6%) rated it as 'good' followed by 'neither poor nor good' (26.7%). It was rated as 'very good' by 16.7% of the farm women. The mouth feel texture was rated as 'good' and 'very good' by 53.3% and 25% of the farm women, respectively. None of the farm women rated it as 'very poor' or 'poor'. Taste was rated as 'very good' by 61.7%, 'good' by 28.3%, and 'neither poor nor good' by 10% of the farm women. The overall acceptability of control was rated as 'very good' by 41.7%, 'good' by 38.3%, and 20 % of farm women were showing a neutral attitude of 'neither poor nor good'.

A study from Cuba indicated an overall liking for zinc and iron enhanced rice variety (Padron *et al.*, 2011). While another study in Nicaragua indicated an overall liking for the control in comparison to nutritionally enriched rice (Montecinos *et al.*, 2011). Two biofortified rice varieties and control were equally accepted by consumers in a study in Bolivia (Woods *et al.*, 2020). In a Colombian study, the biofortified variety had a higher overall acceptance compared to the locally consumed variety (Woods *et al.*, 2020). A study among rice consumers in Bangladesh reported the acceptability of smell, colour, and taste of fortified rice by the majority of the participants (Chakravorty and Akhter, 2014). Moretti *et al.* (2005), and Beinner (2010), reported that fortified rice was acceptable to the panelists. Biofortified rice as a good source of bioavailable zinc as compared to rice postharvest fortified has been reported by Marica Brnić *et al.* (2016). Recommending the appropriate cooking method in retaining micronutrient content in cooked rice and educating the homemakers too plays a vital role in the acceptance of fortified rice (Azam *et al.*, 2021).

The results (Table 1) based on the categorization by Belmes (2019) indicate that the hand feel texture of zinc biofortified rice was moderately acceptable while that of control is acceptable. As for mouth feel texture both the zinc biofortified rice and control is acceptable. The taste of both zinc biofortified rice and control are in the acceptable category. Similarly, the overall acceptability of both the zinc biofortified rice and control were in the acceptable category of hedonic rating. However, both zinc biofortified rice and control were not rated in the highly acceptable category. The plausible reason could be that samples of both zinc biofortified rice and control were hand-pound and most of the consumers are accustomed to eat highly uniform and polished white rice. Therefore it can be concluded that the zinc biofortified rice variety DRR Dhan 45 is equally acceptable to the consumers as the control rice. Rai *et al.* (2019) reported no differences in hedonic scores for nonfortified rice and rice blended with fortified rice kernels and concluded that the acceptability of fortified rice primarily depends on the palatability of the fortified rice. Similarly, no difference in mean hedonic scores for rice fortified with ferric pyrophosphate and non-fortified rice was reported by Radhika *et al.* (2011). No significant difference in overall acceptability between the normal and iron-fortified rice products was reported by Sarkar *et al.* (2015).

Table 1: Mean sensory scores of zinc biofortified rice and control (n-60)

Parameters	Biofortified rice (DRR Dhan 45)		Control (BPT-5204)	
	Sensory Score	Acceptability level	Sensory Score	Acceptability level
Hand feel texture	3.45±0.565[a]	Moderately Acceptable	3.98±0.724[b]	Acceptable
Mouth feel texture	3.63±0.713[b]	Acceptable	4.08±0.590[b]	Acceptable
Taste	4.02±0.873[b]	Acceptable	4.38±0.613[b]	Acceptable
Overall acceptability	3.75±0.750[b]	Acceptable	4.2±0.567[b]	Acceptable

All values are means ± SDs. Values in the same row having same alphabet were not significantly different by independent Student's *t* test ($p<.050$).

The calculated Index of Acceptability (IA) of zinc biofortified rice (DRR Dhan 45) and control has been shown in Table 2 and Figure 1. It shows that the IA was more than 70% for all the parameters for both zinc biofortified rice and control except for the hand feel texture of zinc biofortified rice that obtained a slightly lower score on acceptability (69%). According to Spehar and Santos (2002) for a product to be considered acceptable in terms of its sensory properties, it must obtain a minimum score of 70%. Thus it can be concluded that the sensory attributes of zinc biofortified rice are acceptable to the consumers and they may be motivated to include it in their daily diets. The supply-side issues may be addressed to ensure the availability of zinc biofortified rice in the local markets. Consequently, it may be provided under the various nutritional intervention programs especially for children and women from the vulnerable population.

Table 2: Index of Acceptability for zinc biofortified rice and control

Parameters	Zinc biofortified rice (DRR Dhan 45)	Control (BPT-5204)
	Index of Acceptability	Index of Acceptability
Hand feel texture	69.0	79.6
Mouthfeel texture	72.6	81.6
Taste	80.2	87.6
Overall acceptability	76.5	84.0

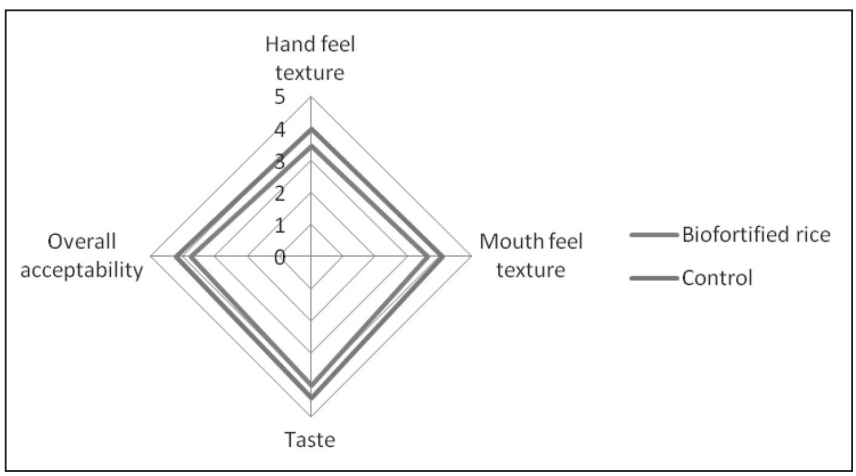

Figure 1: Consumer acceptability scores on a 5 - point hedonic scale
(Scale: 1 very poor; 2- poor; 3- neither poor nor good; 4- good; 5- very good)

3.3 Relationship between socio-economic characteristics and consumer acceptability of zinc biofortified rice

Attempts were made to find the relationship between the personal characteristics of farm women and the acceptability of zinc biofortified rice through the determination of Pearson's correlation coefficient (Table 3). It was found that none of the personal attributes of the farm women indicated a statistically significant relationship. The interaction coefficient for education, membership in organizations and farming experience though positive is insignificant. Whereas, age, family members and farm size have shown negative and insignificant relationship. Thus, it can be concluded that zinc biofortified rice would be accepted irrespective of the age, educational status, family size, farm size, membership status and farming experience of farm women. In a similar study on acceptability of biofortified products, Etumnu (2016) found that consumers' socio-economic characteristics did not have a significant effect on acceptance of biofortified orange flesh sweet potato in Sub-Saharan Africa.

Table 3: Relationships between socio economic characteristics and zinc biofortified rice acceptability

		Acceptability of Zinc biofortified rice
Age	Pearson Correlation	-0.079
	Sig. (2-tailed)	0.548
	N	60
Education	Pearson Correlation	0.042
	Sig. (2-tailed)	0.747
	N	60
Family Members	Pearson Correlation	-0.138
	Sig. (2-tailed)	0.292
	N	60
Membership	Pearson Correlation	0.132
	Sig. (2-tailed)	0.315
	N	60
Farm Size	Pearson Correlation	-0.066
	Sig. (2-tailed)	0.619
	N	60
Experience	Pearson Correlation	0.064
	Sig. (2-tailed)	0.627
	N	60

4. Conclusion

Consumer acceptance of biofortified rice is an important criterion for its incorporation in the daily diets of families. Zinc biofortified rice, DRR Dhan 45 was acceptable to the consumers and the index of acceptability was greater than 70%. Moreover, based on hedonic scoring both the zinc biofortified rice and control are in the acceptable category. The socio-demographic characteristics of the consumers did not show a statistically significant relationship with the acceptability of zinc biofortified rice and it can be concluded that its acceptance is independent of the personal and social attributes of the consumers. Further studies on consumer acceptability may be undertaken with polished rice with a larger sample both in urban and rural areas and also with different age groups of children as consumers. Based on the acceptability of zinc biofortified rice it is recommended that it may be included in the supplementary feeding programs for children and nutritional intervention programs for women to overcome micronutrient malnutrition.

Compliance with ethical standards

NA

Conflict of Interest

Authors declare that they have no conflict of interest

Authors' contribution

Conceptualization of research and designing of experiments (AW, CNN), Conduction of experiment (AW, MMA, BJ), Preparation of manuscript (AW, CNN).

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