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Nutritional Composition and Sensorial Analysis of Amaranth Seed-based Food Products

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ABSTRACT

Background: The preconception period plays a crucial role in women's lives. Nutritional status during this period impacts maternal and child health. Intake of optimal macro and micronutrients is essential for women during the preconception period, to prevent deficiencies like anaemia and metabolic disorders during pregnancy.

Methods: Two amaranth-based food products were developed and sensory evaluation with a 9-point hedonic scale and physicochemical analysis was conducted. A survey among 100 women of reproductive ages at the Primary Healthcare Centre in Kaiwara, Chikkaballapur was conducted in August 2023 for 1 month.

Result: The survey revealed 99% were willing to consume these products for minimum three months. Based on preferences, sweet and savoury products were developed. Nearly 50% and 54% of participants had good overall acceptability for the sweet and savoury, respectively, with none disliking it. A significant preference of texture and taste was seen for the savoury. Higher carbohydrate, fibre, protein and iron contents were present in the sweet (43.42 g/100 g; 14.84 g/100 g; 23.32 g/100 g; 13 mg/100 g respectively). Savoury was higher in energy, crude fat and calcium (563 kcal/100 g, 35.55 g/100 g and 700 mg/100 g respectively). Their positive reception in rural communities suggests they can enhance dietary diversity and health among WRAs.

Key words: Food processing, Physicochemical analysis, Preconception nutrition, Product development, Sensory evaluation, Women of reproductive ages.

INTRODUCTION

The health of future generations begins with the health of those who conceive them (CDC, 2021), hence the preconception period plays an important role in a women's life. The preconception period is defined as the period that is three months before conception (Stephenson *et al*. 2018; Gnoth *et al.,* 2003). It can also be the period at least one year before initiating unprotected sexual intercourse to get pregnant (Dean *et al.,* 2013). As per WHO (2012), it includes the period before pregnancy and the interconception period. It can further be distinguished as the proximal (up to 2 years) and distal period (boundless).

Nutritional status impacts preconception and post pregnancy care. Being underweight [Body Mass Index (BMI) <18.5kg/m^2] can lead to stillbirths, Small for gestational age (SGA) and low birth weight (LBW) infants, while being overweight (BMI≥30 kg/m^2) can lead to preeclampsia, Pregnancy Induced hypertension (PIH) and Gestational diabetes (GDM) (Dean *et al*., 2014). Not only macronutrient, but the micronutrient status also plays an important role. Folic acid and iron supplementation plays a major role in prevention of Neural tube Defects (NTDs). Micronutrients like calcium help in improving Maternal and Child Health (MCH) outcomes if taken pre-pregnancy as it would be an added benefit in unplanned pregnancies. Folic acid, B and C vitamins effect early foetal development (Dean *et al*., 2014). Hence, it is necessary for women to supplement these micronutrients before pregnancy. To meet these micronutrient needs among WRAs, we developed food products in line with the choices of women in Kaiwara. Sensory evaluation and physicochemical analysis of the two products was conducted.

Sensory evaluation plays a critical role in developing and accepting new food products, specifically in ensuring that they meet consumer preferences and expectations. The 9-point hedonic scale is a commonly used method for sensory evaluation that ranges from 'dislike extremely' to 'like extremely'. It offers an intuitive way for consumers to express their sensory experiences, making it an important part in development of food products (Meilgaard *et al*., 2007). This scale is valuable as it is user friendly and provides a reliable measure of overall acceptability (Lawless and Heymann, 2010).

Hedonic scales are categorized into the 3-point, 5-point, 7-point and the more commonly used 9-point scale. Each has its own set of advantages, with the 9-point scale

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preferred for its precision, allowing for refined consumer feedback (Peryam and Pilgrim, 1957). The need for sensory evaluation is much more than preference assessment and is required for understanding the sensory attributes that drive consumer choices (Stone *et al.*, 2012). Nutritional analysis plays a significant role in guiding healthy eating, maintaining food quality, assessing diet quality and nutritional assessment (Elmadfa and Meyer, 2010). It has also been observed that 76% consumers check labels before buying any food products (Jain *et al.*, 2018). Thus, testing food products is essential to give the right information to consumers and ensure their potential in fulfilling nutrient deficiencies. Hence, nutrition analysis was conducted for the food products.

In the present study, amaranth seeds (Fig 1) have been used for enhancing the nutritional composition in the food product. Amaranth seeds have gained attention for their remarkable nutritional profile, which is beneficial for women of reproductive ages (WRAs). Amaranthus is a *pseudocereal* with more than 60 species, of which only three species are used as edible grains: Amaranthus hypochondriacus, Amaranthus cruentus and Amaranthus caudatus (Kaur *et al.*, 2010). It is known to have protein content between 13-18% (or 12.5-16 g/100 g) which is much higher than wheat or rice (Bressani, 2003; Bressani *et al.*, 1987).

Moreover, amaranth grains have a well-balanced amino acid profile (Drzewiecki, 2001) along with lysine being twice or thrice higher as compared to other cereals. It is also higher in other amino acids like methionine, cysteine, tryptophan, threonine, phenylalanine and leucine which are lower in other cereals like wheat (Cotovanu and Mironeasa, 2021; Bressani *et al*., 1987; Pavlik, 2012; Palombini *et al*., 2013; Paucar-Menacho *et al*., 2018). Amaranth is also high in dietary fibre which is required for a healthy gut and digestion (Caselato-Sousa and Amaya-Farfán, 2012). It is also high in iron which was highlighted in a study where it could meet a significant portion of the daily iron requirements, aiding in iron-deficiency anaemia (Martínez and Palma, 2011).

Furthermore, it contains bioactive compounds that help in reducing oxidative stress and support the immune system (Alvarez-Jubete *et al*., 2010). These nutrients are essential for addressing common nutritional deficiencies observed in WRAs, such as anaemia and calcium deficiency, which are prevalent issues among this age group. Incorporating amaranth seeds into the diet can enhance overall nutritional status, supporting maternal health and foetal development, along with reducing chances of non-communicable diseases like diabetes and hypertension (Tucker, 1986; Patel *et al*., 2022).



Fig 1: Amaranth seeda.

In Karnataka, amaranth, locally known as “Rajgira,” is traditionally consumed in various forms, including porridges, flatbreads and snacks. Although it has nutritional advantages, use of amaranth in contemporary food products is uncommon. Using it in modern food products can help in leveraging its nutritional benefits and catering to consumer tastes (Becker, 2013). Evaluation of sensory properties of amaranth seed-based food products using the 9-point hedonic scale might provide insights into its acceptability among WRAs in rural Karnataka.

This study was conducted to assess the sensory attributes and consumer acceptance of amaranth seed-based food products among WRAs, implementing the 9-point hedonic scale along with physicochemical properties to assess the nutritional composition of the products.

MATERIALS AND METHODS

For the sweet, the ingredients used included amaranth seeds (Nature Land Organics, Rajasthan, India), dates (Lion, Tiruchirappalli, India), flax seeds (Nourish you, Hyderabad, India), sunflower seeds (Nourish you, Hyderabad, India), pumpkin seeds (Nourish you, Hyderabad, India), sesame seeds (Nourish you, Hyderabad, India), defatted soya flour (Value life Essentials, Hyderabad, India) and groundnuts (Organic Tattva, Uttar Pradesh, India).

For the savoury, the ingredients used included puffed rice (Patanjali, Madhya Pradesh, India) amaranth seeds (Nature Land Organics, Rajasthan, India), groundnuts (Organic Tattva, Uttar Pradesh, India), moringa powder (Saptamveda, Pune, India), mustard seeds (Pronature, Bengaluru, India), refined sunflower oil (Sundrop, Bengaluru, India), salt (Tata company, India) and turmeric powder (Aashirvaad, Kolkata, India).

Preparation of the food products

Sweet ladoo

Ladoo is an Indian Traditional sweet that is usually made from a mixture of flour, sugar and ghee (Sudha *et al.*, 2024). These ingredients can vary as per the recipe which is then shaped into a ball. In the present study, ladoos using amaranth seeds were made. The amaranth seeds were popped in a pan at 200°C for 15 seconds until complete popping was achieved (Amare *et al*., 2015). This was done to provide a nutty and crunchy flavour to the products (Sood *et al*., 2009). 20 g of the popped amaranth seeds, 25 grams defatted soya flour, 50 grams deseeded dates, 15 grams roasted groundnuts and 5 grams each of flax seeds,

pumpkin seeds, sunflower seeds and sesame seeds were taken. All the ingredients were then blended in a mixer and then formed into Ladoo's.

Savoury mixture

The amaranth seeds were popped in a pan at 200°C for 15 seconds until complete popping was achieved (Amare *et al*., 2015). 60 grams of the popped amaranth seeds, 30 grams of puffed rice, 15 grams roasted groundnuts, 5 grams of moringa powder and mustard seeds with turmeric for tempering along with salt as per taste were taken. In a pan, 20 ml of sunflower oil was taken and mustard seeds and turmeric was added. This tempering was then added to the other ingredients (puffed rice, popped amaranth, roasted peanuts, salt and moringa powder). Mix well.

Physicochemical analysis of the food products

Nutritional parameters tested for the products included moisture (Bureau of Indian Standards, 1989), total ash (Bureau of Indian Standards, 1989), energy, carbohydrates (Bureau of Indian Standards, 2007), crude protein (Bureau of Indian Standards, 1973), total fibre (Bureau of Indian Standards, 1984), soluble fibre (Bureau of Indian Standards, 1984), insoluble fibre (Bureau of Indian Standards, 1984), crude fat (Bureau of Indian Standards, 1989), calcium (Bureau of Indian Standards, 1975), iron (Titration with potassium permanganate) (Murray, 1924), folic acid (vitamin B9) (Liquid Chromatography-Mass Spectrometry/Mass Spectrometry (LCMS/MS)) and ascorbic acid (vitamin C) (High-Performance Liquid Chromatography (HPLC)) (Ekinci and Kadakal, 2005).

Sensory evaluation of the food products

A survey was conducted in August 2023, asking participants about their taste preferences (sweet, sour, bitter and savoury) along with the form of food product (porridge, ladoo and mixture) and the willingness to consume the products for at least 3 months. Based on the results from the survey, two food products (sweet ladoo and savoury mixture) were developed.

A sensory evaluation was done using the 9-point hedonic scale (Table 1) in their local language (Kannada) or English (Annexure I) among 100 WRAs in the Primary Healthcare Centre, Chikkaballapur, Kaiwara.

Sampling

The participants were chosen through random sampling. Sensory evaluation was conducted based on overall acceptability, appearance/colour, smell/odour, taste/flavour and texture/mouthfeel. The scale had the following 9 points to be selected by the participants.

RESULTS AND DISCUSSION

As seen in Table 2, the moisture content, carbohydrates, protein, crude fat and fibre in the ladoos (9.95 g/100 g; 43.54 g/100 g; 23.32 g/100 g; 20.52 g/100 g and 14.84 g/100 g respectively) were higher as compared to the mixture. Furthermore, energy was higher in the mixture (563 kcal/100 g). Among minerals, calcium was higher in the mixture (700 mg/100 g) and iron was higher in the ladoos (13 mg/100 g). Among vitamins, folic acid was high in the mixture (4.56 mcg/100 g) due to higher presence of amaranth seeds and ascorbic acid (5 mg/100 g) was higher in the ladoos.

As per the survey conducted, majority (99.5%) of the respondents were willing to try a new food product and 99% were willing to consume it for at least 3 months. As seen in Fig 2, 24.8% preferred sweet and 69.2% preferred savoury foods. 6% preferred both sweet and savoury foods.

Table 1: 9-point hedonic scale.

Dislike extremely	**1**
Dislike strongly	2
Dislike moderately	3
Dislike slightly	4
Neither like nor dislike	5
Like slightly	6
Like moderately	7
Like strongly	8
Like extremely	9

Table 2: Physicochemical analysis.

Parameter	Amaranth ladoo (Sweet)	Amaranth mixture (Savoury)
Parameter (per 100 g)	Nutrient value	Nutrient value
Moisture (g)	9.95	0.76
Total ash (g)	2.78	2.91
Energy (kcal)	452	563
Carbohydrates (g)	43.54	38.75
Crude protein (g)	23.31	22.03
Total fibre (g)	14.84	11.30
Soluble fibre (g)	1.30	1.16
Insoluble fibre (g)	13.54	10.14
Crude fat (g)	20.52	35.55
Calcium (mg)	460	700
Iron (mg)	13	6
Folic acid (mcg)	2	4.56
Ascorbic acid (mg)	5	2.5

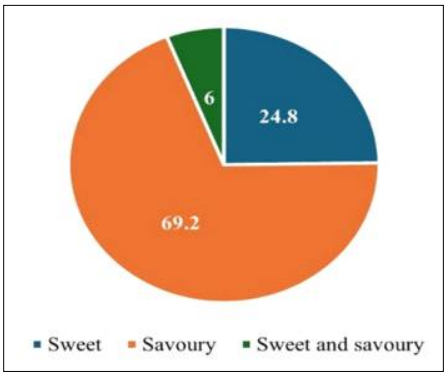


Fig 2: Taste preferences among WRAs.

Furthermore, 19% preferred the food to be in the form of a ladoo and 70.3% preferred the food to be in the form of a mixture, 3.8% wanted it to be in the form of a ladoo or a mixture and 4% preferred it to be in the form of a porridge and mixture. Keeping in mind the choice of majority of the respondents (i.e., savoury mixture and sweet ladoo), the two food products were developed.

Sensory evaluation of the two products i.e., amaranth ladoo and amaranth mixture had the results as represented in the graphs below (Fig 3 and Fig 4).

As seen in Fig 3, 36% of participants moderately liked the texture of the ladoo and 8% slightly liked it, 42% moderately liked the taste and 12% liked it slightly. Furthermore, 38% moderately liked the smell and 10% liked it extremely; 48% moderately liked the appearance and 8% liked it extremely and half of the participants (50%) found the overall acceptability to be moderate and 6% liked it extremely. Additionally, none of the participants disliked the ladoo.

As seen in Fig 4, 38% of participants strongly liked the texture of the mixture and only 2% had a neutral response and neither liked nor disliked it, 42% moderately liked the taste and 8% liked it extremely, 46% moderately liked the smell and only 4% had a neutral response and neither liked nor disliked it, 40% strongly liked the appearance and 8% liked it extremely. Lastly, 54% found the overall acceptability to be moderate and only 2% liked it extremely.

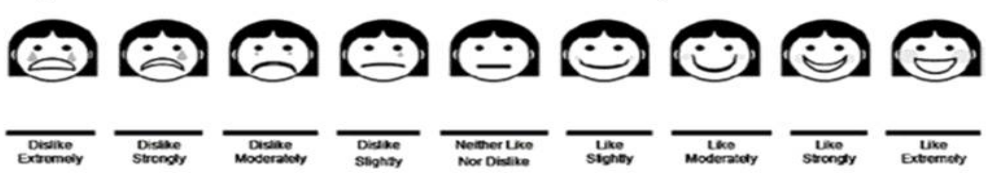
The present study was conducted with an objective to make amaranth seed based nutrient rich food products for WRAs during the preconception period. Amaranth is an ancient crop with a rich history and cultivation and is believed to have originated in South America. It is rich in protein and amino acids, fibre, iron, folic acid, calcium and other nutrients (Kaur *et al*., 2010; Bressani *et al*., 2003; Yilma *et al*., 2025). On an average, 100g of amaranth seeds compromise 61.3-76.5 g carbohydrates, 13.1-21.5 g protein (especially lysine), 5.6-10.9 g fat and 2.7-5 g fibre. It also provides 7.61 mg iron per 100 g and folate 24.65 mcg per100 g (Yilma *et al*., 2025; Zhu, 2023; Longvah *et al.*, 2017). These nutrients are significant to fulfil nutritional deficiencies during the preconception period.

Annexure I: 9-point hedonic scale:

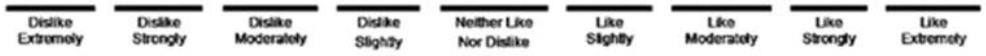
Name: Age (Yrs): Date:

INSTRUCTIONS: You are presented with **AMARANTH LADOO/MIXTURE**. Kindly tick (ü) how much you like or dislike for each characteristic. You can taste the product more than once.

1. How do you like the **OVERALL ACCEPTIBILITY** of the product?



2. How do you like the **APPERANCE/COLOUR** of the product?



3. How do you like the **SMELL/ODOUR** of the product?



4. How do you like the **TASTE/FLAVOUR** of the product?



5. How do you like the **TEXTURE/MOUTHFEEL** of the product?

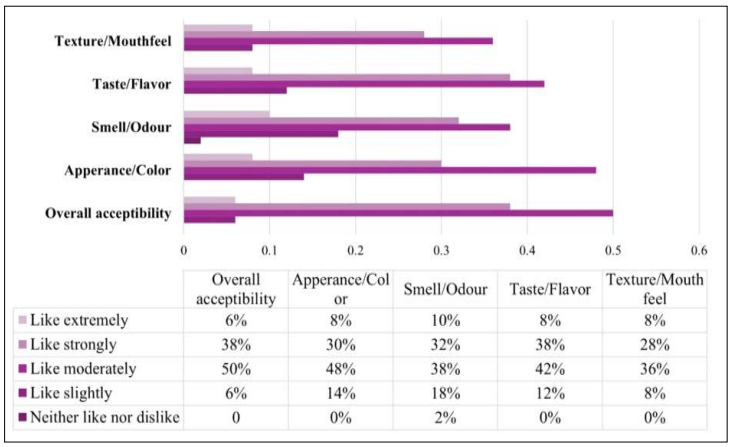


(Adapted from Gabriel *et al*., 2005).

Apart from amaranth, other ingredients used in the food products are also nutritionally rich. Dates are high in carbohydrates, total fibre and iron (Hasan *et al*., 2022; Ibrahim *et al*., 2021). Flax seeds, Pumpkin seeds, sesame seeds and sunflower seeds, along with defatted soya flour are high in protein, mono-unsaturated and poly-unsaturated fats (Khedr, 2010; Zhu, 2023; Xing *et al*., 2018). Additionally, these seeds are known to regulate hormones and support mensural cycle regularity (Zafar *et al*., 2024). Furthermore, puffed rice used in the savoury mixture is known to be a good source of carbohydrates and energy (Longvah *et al*., 2017). Moringa powder is high in calcium, vitamin A, iron, potassium and protein (Gopalakrishnan *et al*., 2016; Zungu *et al*., 2020).

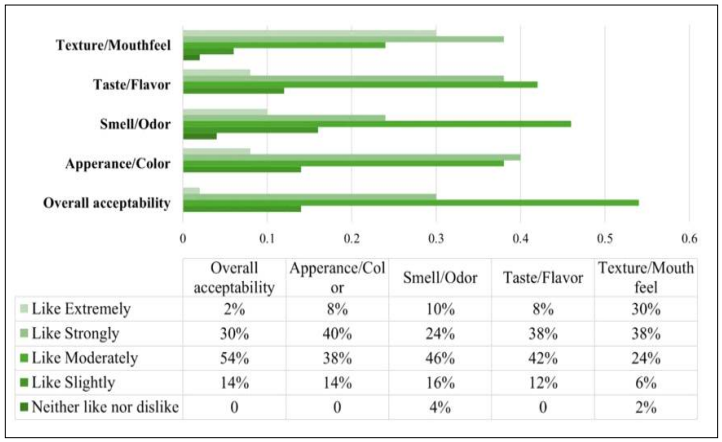
Sensory evaluation helps to describe the products based on the overall acceptability, colour, smell, taste and texture. The amaranth based food products were developed to potentially fulfil the nutrient deficiencies in women of reproductive ages during the preconception period. The forms of these products (sweet ladoo and savoury mixture) are already liked by the Indian population and align with the Indian cuisine (Arora *et al*., 2023). The products in the present study had good overall acceptability which were in line with studies conducted in Rajasthan where amaranth and green gram-based cookies were well accepted and Punjab where 60% overall acceptability of the amaranth based products was seen (Anamika and Vishakha, 2017; Chauhan *et al*., 2016). Another study in Africa had similar results where the acceptability of amaranth-based products was more as compared to the millet-based products (Isaac-Bamgboye *et al.,* 2019). A study conducted in Romania also saw a good acceptance of food products made from wheat and amaranth (Man *et al*., 2017).

Both the food products were not only well accepted but also had a rich nutritional profile. The high moisture content in the ladoos can be attributed to the dates (Hasan *et al*., 2022), carbohydrates and iron content in the ladoos can be attributed to the addition of dates and amaranth (Hasan *et al*., 2022; Ibrahim *et al*., 2021; Yilma *et al*., 2025). High protein content in the ladoos can be likely due to the defatted soya flour, flax seeds, pumpkin seeds and amaranth (Ganorkar and Jain, 2013; Yilma *et al*., 2025; Xing *et al*., 2018; Syed *et al*., 2019). High crude fat in the ladoos can be due to the addition of flaxseeds (Ishag *et al*., 2019), pumpkin seeds (Syed *et al*., 2019), sesame seeds (Thakur *et al*., 2017) and sunflower seeds (Puraikalan and Scott, 2023). High fibre in the ladoos is attributed to the flaxseeds and dates (Ishag *et al*., 2019; Hasan *et al*., 2022)



	Overall acceptibility	Apperance/Color	Smell/Odour	Taste/Flavor	Texture/Mouth feel
Like extremely	6%	8%	10%	8%	8%
Like strongly	38%	30%	32%	38%	28%
Like moderately	50%	48%	38%	42%	36%
Like slightly	6%	14%	18%	12%	8%
Neither like nor dislike	0	0%	2%	0%	0%

Fig 3: Sensory evaluation - amaranth ladoo.



	Overall acceptability	Apperance/Color	Smell/Odor	Taste/Flavor	Texture/Mouth feel
Like Extremely	2%	8%	10%	8%	30%
Like Strongly	30%	40%	24%	38%	38%
Like Moderately	54%	38%	46%	42%	24%
Like Slightly	14%	14%	16%	12%	6%
Neither like nor dislike	0	0	4%	0	2%

Fig 4: Sensory evaluation-amaranth mixture.

and high vitamin C or ascorbic acid is due to the presence of dates (Longvah *et al.*, 2017).

Furthermore, energy was higher in the mixture attributed due to the puffed rice (Longvah *et al.*, 2017). Calcium was also found to be higher in the mixture due to higher amounts of amaranth (Aderibigbe *et al.*, 2022) and moringa powder (Zungu *et al.*, 2020). Folic acid was content was high in the mixture due to higher presence of amaranth seeds (Soriano-García and Aguirre-Díaz., 2019).

As seen, both the amaranth seed-based food products are well accepted and nutritionally high. Studies indicate that food products made with dates are considered nutritionally better as compared to those with sugar (Manickavasagan *et al.*, 2013). An increased intake of sugar can lead to a higher risk of non-communicable diseases like obesity, type-2 diabetes and other metabolic disorders which in turn can affect pregnancy rates in women (García-Ferreyra *et al.*, 2021). Dates, on the other hand have a better nutritional profile can be a healthier alternative to sugar (Manickavasagan *et al.*, 2013; Sayas-Barberá *et al.*, 2023).

Additionally, snacking in India is preferred with intake of deep-fried foods like samosas, mixtures, vadas, *etc.* making them more calorie dense, high in sodium and intake of excess oil which can lead to obesity, hypertension and other metabolic disorders (Ganpule *et al.*, 2023). Too much intake of fried foods can also lead to higher chances of gestational diabetes mellitus if taken in excess before pregnancy (Ghidurus *et al.*, 2010; Gadiraju *et al.*, 2015; Bao *et al.*, 2014). Hence, to make it healthier, the savoury mixture was roasted and not fried and was made with nutritionally rich ingredients to support maternal and child health.

Thus, both the food products can be consumed in the preconception period by WRAs to prevent deficiencies, have better child health outcomes and healthier pregnancies.

CONCLUSION

Preconception nutrition is essential to ensure optimal maternal and child health outcomes and optimal nutrition plays a major role during this period. The development of nutrient-rich, amaranth seed-based food products tailored for WRAs during the preconception period holds significant promise in addressing key micronutrient deficiencies. By incorporating locally accepted, culturally relevant and nutritionally dense ingredients such as amaranth, dates, oil seeds and moringa, these products not only provide essential macro- and micronutrients but also offer a healthier alternative to traditional high-fat, high-sugar snacks.

Amaranth seeds that are rich in protein and folic acid can be incorporated into locally available food products as a way of fortification, to ensure wholesome nutrition. The positive overall acceptance and nutritional profiling of the food products indicates the potential to be included in the regular diet which could help with addressing nutritional deficiencies among WRAs. Expanding the awareness and scale up of such functional foods to other rural and urban communities in Karnataka and other cities can contribute to public health strategies aimed at enhancing maternal nutrition, reducing the risk of adverse pregnancy outcomes and supporting long-term health for the mother and child.

Conflict of interest

The authors declare that there is no conflict of interest regarding publication of this paper.

REFERENCES

Aderibigbe, O.R., Ezekiel, O.O., Owolade, S.O., Korese, J.K., Sturm, B. and Hensel, O. (2022). Exploring the potentials of underutilized grain amaranth (*Amaranthus* spp.) along the value chain for food and nutrition security: A review. *Critical Reviews in Food Science and Nutrition*. **62(3):** 656-669. doi: 10.1080/10408398.2020.1825323.

Alvarez-Jubete, L., Arendt, E.K. and Gallagher, E. (2010). Nutritive value and chemical composition of pseudocereals as gluten-free ingredients. *International Journal of Food Sciences and Nutrition*. **61(3):** 240-257. doi: 10.1080/09637480902950597.

Amare, E., Mouquet-Rivier, C., Servent, A., Morel, G., Adish, A., Haki, G.D. (2015). Protein quality of amaranth grains cultivated in Ethiopia as affected by popping and fermentation. *Food and Nutrition Sciences*. **6(1):** 38-48. doi: 10.4236/fns. 2015. 61005.

Anamika, G. And Vishakha, S. (2017). Organoleptic evaluation of nutritious biscuits developed from amaranth seeds. *International Journal of Science, Environment and Technology*. **(6):** 98-103.

Arora, L., Aggarwal, R., Dhaliwal, I., Gupta, O.P. and Kaushik, P. (2023). Assessment of sensory and nutritional attributes of foxtail millet-based food products. *Frontiers in Nutrition*. **10:** 1146545. doi: 10.3389/fnut.2023.1146545.

Bao, W., Tobias, D.K., Olsen, S.F. and Zhang, C. (2014). Pre-pregnancy fried food consumption and the risk of gestational diabetes mellitus: A prospective cohort study. *Diabetologia*. **57:** 2485-2491. doi: 10.1007/s00125-014-3382-x.

Becker, R. (2013). Amaranth: Chemistry, Nutrition and Food Applications. CRC Press.

Bressani, R. (2003). Amaranth. In: B. Caballero, L.C. Trugo and P.M. Finglas, *eds.* Encyclopedia of Food Sciences and Nutrition. Academic Press.

Bressani, R., Gonzales, J.M., Zuñiga, J., Breuner, M., Elias, L.G. (1987). Yield selected chemical composition and nutritive value of 14 selections of Amaranth grain representing four species. *Journal of the Science of Food and Agriculture.* **38(4):** 347-356. doi: 10.1002/jsfa.2740380407.

Bureau of Indian Standards. (1973). IS 7219:1973 - Method for determination of protein in foods and feeds. New Delhi: Bureau of Indian Standards. Retrieved from https://archive.org/details/gov.in.is.7219.1973.

Bureau of Indian Standards. (1975). IS 7874-2:1975 - Methods of tests for animal feeds and feeding stuffs, Part 2: Minerals and trace elements. New Delhi: Bureau of Indian Standards. Retrieved from https://law.resource.org/pub/in/bis/S06/is.7874.2.1975.pdf.

Bureau of Indian Standards. (1984). IS 11062:1984 - Method for estimation of total dietary fibre in foodstuffs. New Delhi: Bureau of Indian Standards. Retrieved from https://law.resource.org/pub/in/bis/S06/is.11062.1984.pdf

Bureau of Indian Standards. (1989). IS 12711:1989 - Bakery products – Methods of analysis. New Delhi: Bureau of Indian Standards. Retrieved from https://law.resource.org/pub/in/bis/S06/is.12711.1989.pdf.

Bureau of Indian Standards. (2007). IS 1656:2007 - Milk-cereal based complementary foods – Specification (Fourth Revision). New Delhi: Bureau of Indian Standards. Retrieved from https://law.resource.org/pub/in/bis/S06/is.1656.2007.pdf.

Caselato-Sousa, V.M. and Amaya-Farfán, J. (2012). State of knowledge on amaranth grain: A comprehensive review. *Journal of Food Science*. **77(4):** 93-104. doi: 10.1111/j.1750-3841.2012.02645.x.

CDC. (2021). Preconception health and health care. Centers for Disease Control and Prevention. [online] Available at: https://www.cdc.gov/preconception/index.html [Accessed 26 May 2025].

Chauhan, A., Saxena, D.C. and Singh, S. (2016). Physical, textural and sensory characteristics of wheat and amaranth flour blend cookies. *Cogent Food and Agriculture*. **2(1):** 1125773. doi: 10.1080/23311932.2015.1125773.

Cotovanu, I., Mironeasa, S. (2021). Impact of different amaranth particle sizes addition level on wheat flour dough rheology and bread. *Foods*. 10(7): 1539. doi: 10.3390/foods10071539.

Dean, S., Rudan, I., Althabe, F., Webb Girard, A., Howson, C., Langer, A., Lawn, J., Reeve, M.E., Teela, K.C., Toledano, M. and Venkatraman, C.M. (2013). Setting research priorities for preconception care in low-and middle-income countries: Aiming to reduce maternal and child mortality and morbidity. *PLOS Medicine*. **10(9):** e1001508. doi: 10.1371/journal.pmed.1001508.

Dean, S.V., Lassi, Z.S., Imam, A.M. and Bhutta, Z.A. (2014). Preconception care: Nutritional risks and interventions. *Reproductive Health*. **11:** 1-15. doi: 10.1186/1742-4755-11-S3-S3.

Drzewiecki, J. (2001). Similarities and differences between Amaranthus species and cultivars and estimation of outcrossing rate on the basis of electrophoretic separations of urea-soluble seed proteins. *Euphytica*. **119(3):** 279-287. doi: 10.1023/A:1017563703608.

Ekinci, R. and Kadakal, C. (2005). Determination of seven water soluble Vitamins in Tarhana, a Traditional Turkish Cereal Food, by High-Performance Liquid Chromatography. Pamukkale University, College of Engineering, Department of Food Engineering, Turkey.

Elmadfa, I. And Meyer, A.L. (2010). Importance of food composition data to nutrition and public health. *European Journal of Clinical Nutrition*. **64(3):** S4-S7. doi: 10.1038/ejcn.2010.202.

Gabriel, A.A., Fernandez, C.P. and Tiangson-Bayaga, C.L.P. (2005). Consumer acceptance of Philippine orange drink as an iron-fortified beverage for Filipino women. *Food Science and Technology Research*. **11(3):** 269-277. doi: 10.3136/fstr.11.26.

Gadiraju, T.V., Patel, Y., Gaziano, J.M. and Djoussé, L. (2015). Fried food consumption and cardiovascular health: A review of current evidence. *Nutrients*. **7(10):** 8424-8430. doi: 10.3390/nu7105404.

Ganorkar, P.M. and Jain, R.K. (2013). Flaxseed-a nutritional punch. *International Food Research Journal*. **20(2).**

Ganpule, A., Dubey, M., Pandey, H., Venkateshmurthy, N.S., Green, R., Brown, K.A., Maddury, A.P., Khatkar, R., Jarhyan, P., Prabhakaran, D. and Mohan, S. (2023). Snacking behavior and association with metabolic risk factors in adults from north and south India. *The Journal of Nutrition*. **153(2):** 523-531. doi: 10.1016/j.tjnut.2022.12.032.

García-Ferreyra, J., Carpio, J., Zambrano, M., Valdivieso-Mejía, P. and Valdivieso-Rivera, P. (2021). Overweight and obesity significantly reduce pregnancy, implantation and live birth rates in women undergoing in vitro fertilization procedures. *JBRA Assisted Reproduction*. **25(3):** 394. doi: 10.5935/1518-0557.20200105.

Ghidurus, M.I.H.A.E.L.A., Turtoi, M., Boskou, G., Niculita, P.E.T.R.U. and Stan, V. (2010). Nutritional and health aspects related to frying (I). *Romanian Biotechnological Letters*. **15(6):** 5675-5682.

Gnoth, C., Godehardt, D., Godehardt, E., Frank Herrmann, P. and Freundl, G. (2003). Time to pregnancy: Results of the German prospective study and impact on the management of infertility. *Human Reproduction*. **18(9):** 1959-1966. doi: 10.1093/humrep/deg366.

Gopalakrishnan, L., Doriya, K. And Kumar, D.S. (2016). *Moringa oleifera*: A review on nutritive importance and its medicinal application. *Food Science and Human Wellness*. **5(2):** 49-56. doi: 10.1016/j.fshw.2016.04.001.

Hasan, F., Nazir, A., Sobti, B., Tariq, H., Karim, R., Al-Marzouqi, A.H. and Kamal-Eldin, A. (2022). Dehydration of date fruit (*Pheonix dactylifera* L.) For the production of natural sweet powder. *NFS Journal.* **27:** 13-20. doi: 10.1016/j.nfs.2022.02.002.

Ibrahim, S.A., Ayad, A.A., Williams, L.L., Ayivi, R.D., Gyawali, R., Krastanov, A. and Aljaloud, S.O. (2021). Date fruit: A review of the chemical and nutritional compounds, functional effects and food application in nutrition bars for athletes. *International Journal of Food Science and Technology*. **56(4):** 1503-1513. doi: 10.1111/ijfs.14783.

Isaac-Bamgboye, F.J., Edema, M.O. and Oshundahunsi, O.F. (2019). Nutritional quality, physicohemical properties and sensory evaluation of amaranth-kunu produced from fermented grain amaranth (amaranthus hybridus). *Annals: Food Science and Technology.* **20(2).**

Ishag, O.A.O., Khalid, A.A., Abdi, A., Erwa, I.Y., Omer, A.B. and Nour, A.H. (2019). Proximate composition, physicochemical properties and antioxidant activity of flaxseed. *Ann Res Review Biol*. 1-10. doi: 10.9734/ARRB/2019/v34i230148.

Jain, S., Gomathi, R. And Kar, S.S. (2018). Consumer awareness and status of food labeling in selected supermarkets of Puducherry: An exploratory study. *International Journal of Advanced Medical and Health Research*. **5(1):** 36-40. doi: 10.4103/IJAMR.IJAMR_48_17.

Kaur, S., Singh, N., Rana, J.C. (2010). Amaranthus hypochondriacus and Amaranthus caudatus germplasm: Characteristics of plants, grain and flours. *Food Chemistry*. **123(4):** 1227-1234. doi: 10.1016/j.foodchem.2010.05.091.

Khedr, A.A. (2010). Comparative effects of flaxseed, sesame seed and pumpkin seed on health of hypercholesterolemic rats. *Egyptian Journal of Nutrition and Health*. **5(1):** 71-82.

Lawless, H.T. and Heymann, H. (2010). Sensory Evaluation of Food: Principles and Practices. Springer.

Longvah, T., Ananthan, R., Bhaskarachary, K. and Venkaiah, K. (2017). Indian Food Composition Tables 2017. Hyderabad: National Institute of Nutrition, Indian Council of Medical Research. Available at: https://www.researchgate.net/publication/313226719_Indian_food_Composition_ Tables [Accessed 28 May 2025].

Man, S., Pãucean, A., Muste, S., Chi', M.S., Pop, A. And Călian, I.D. (2017). Assessment of amaranth flour utilization in cookies production and quality. *J. Agroaliment. Process. Technol*. **23(2):** 97-103.

Manickavasagan, A., Mathew, T.A., Al-Attabi, Z.H. and Al-Zakwani, I.M. (2013). Dates as a substitute for added sugar in traditional foods-A case study with idli. *Emirates Journal of Food and Agriculture (EJFA)*. **25(11).** doi: 10.9755/ejfa.v25i11.14920.

Martínez, M.M. and Palma, M. (2011). Nutritional properties and health benefits of amaranth. *Food Chemistry*. **129(1):** 321-327.

Meilgaard, M., Civille, G.V. and Carr, B.T. (2007). Sensory Evaluation Techniques. *CRC Press*. doi: 10.1201/9781003040729.

Murray, M.M. (1924). A Method for the Estimation of Iron in small quantities in Biological Substances. *Biochemical Journal*. **18(5):** 852. doi: 10.1042/bj0180852.

Palombini, S.V., Claus, T., Maruyama, S.A., Gohara, A.K., Souza, A.H.P., de Souza, N.E., Visentainer, J.V., Gomes, S.T.M., Matsushita, M. (2013). Evaluation of nutritional compounds in new amaranth and quinoa cultivars. *Food Science and Technology Campinas*. **33(2):** 339-344. doi: 10.1590/S0101-20612013005000051.

Patel Dasharath, Pinto Suneeta, Patel Sunil (2022). Amaranth and Date Flavoured Milk. *Bhartiya Krishi Anusandhan Patrika*. **36(4):** 304-312. doi: 10.18805/BKAP355.

Paucar-Menacho, L.M., Dueñas, M., Peñas, P., Frias, J., Martínez-Villaluenga, C. (2018). Effect of dry heat puffing on nutritional composition, fatty acid, amino acid and phenolic profiles of pseudocereals grains. *Polish Journal of Food and Nutrition Sciences*. **68(4):** 289-297. doi: 10.1515/pjfns-2018-0005.

Pavlík, V. (2012). The revival of Amaranth as a third-millennium food. *Neuroendocrinology Letters*. **33(3):** 3-7.

Peryam, D.R. and Pilgrim, F.J. (1957). Hedonic scale method of measuring food preferences. *Food Technology*. **11:** 9-14.

Puraikalan, Y. and Scott, M. (2023). Sunflower seeds (helianthus Annuus) and health benefits: A review. *Recent Progress in Nutrition*. **3(3):** 1-5. doi: 10.21926/rpn.2303010.

Sayas-Barberá, E., Paredes, C., Salgado-Ramos, M., Pallarés, N., Ferrer, E., Navarro-Rodríguez de Vera, C. and Pérez-Álvarez, J.Á. (2023). Approaches to enhance sugar content in foods: Is the date palm fruit a natural alternative to sweeteners?. *Foods*. **13(1):** 129. doi: 10.3390/foods13010129.

Sood, A., Sharma, H.R., Verma, R. (2009). Development and nutritional evaluation of linseed supplemented amaranth and sesame based sweet balls. *Asian Journal of Dairy and Food Research*. **28(1):** 49-53.

Soriano-García, M. and Aguirre-Díaz, I.S. (2019). Nutritional functional value and therapeutic utilization of Amaranth. In Nutritional value of amaranth. IntechOpen.

Stephenson, J., Heslehurst, N., Hall, J., Schoenaker, D.A., Hutchinson, J., Cade, J.E., Poston, L., Barrett, G., Crozier, S.R., Barker, M. and Kumaran, K. (2018). Before the beginning: Nutrition and lifestyle in the preconception period and its importance for future health. *The Lancet*. **391(10132):** 1830-1841. doi: 10.1016/S0140-6736(18)30311-8.

Stone, H., Bleibaum, R.N. and Thomas, H.A. (2012). Sensory Evaluation Practices. Academic Press.

Sudha K.V., Karakannavar J. Sarojani, Inamdar Basavraj, Yenagi B. Nirmala (2024). Development and Nutritional Evaluation of Foxtail Millet (*Setaria italica*) based Laddu. *Asian Journal of Dairy and Food Research*. **43(4):** 679-683. doi: 10.18805/ajdfr.DR-1773.

Syed, Q.A., Akram, M. and Shukat, R. (2019). Nutritional and therapeutic importance of the pumpkin seeds. *Seed*. **21(2):** 15798-15803. doi: 10.26717/BJSTR.2019.21.003586.

Thakur, V., Paroha, S. and Mishra, R.P. (2017). Chemical characterization and fatty acid composition of different sesame verities. *International Journal of Current Microbiology and Applied Science*. **6:** 1936-1943. doi: 10.20546/ijcmas.2017.612.221.

Tucker, J.B. (1986). Amaranth: The once and future crop. Bioscience. **36(1):** 9-13. doi: 10.2307/1309789.

WHO (2012). Guideline: Daily iron and folic acid supplementation in pregnant women. World Health Organization. [online] Available at: https://iris.who.int/bitstream/handle/10665/77770/?sequence=1 [Accessed 24 May 2025]

Xing, Q., de Wit, M., Kyriakopoulou, K., Boom, R.M. and Schutyser, M.A. (2018). Protein enrichment of defatted soybean flour by fine milling and electrostatic separation. *Innovative Food Science and Emerging Technologies*. **50:** 42-49. doi: 10.1016/j.ifset.2018.08.014.

Yilma, M.T., Eifa, A., Belayneh, M. and Orsango, A.Z. (2025). Effect of amaranth-containing dietary intervention in improving haemoglobin concentration: A systematic review and meta-analysis. *Public Health Reviews*. **45:** 1607597. doi: 10.3389/phrs.2024.1607597.

Zafar, M., Rabail, R., Bibi, S., Jebreen, A., Khan, M.A. and Aadil, R.M. (2024). Seed Cycling: Approach for Polycystic Ovarian Syndrome. *Food and Humanity*. 100274. doi: 10.1016/j.foohum.2024.100274.

Zhu, F. (2023). Amaranth proteins and peptides: Biological properties and food uses. *Food Research International.* **164:** 112405. doi: 10.1016/j.foodres.2022.112405.

Zungu, N., Van Onselen, A., Kolanisi, U. and Siwela, M. (2020). Assessing the nutritional composition and consumer acceptability of *Moringa oleifera* leaf powder (MOLP)-based snacks for improving food and nutrition security of children. *South African Journal of Botany*. **129:** 283-290. doi: 10.1016/j.sajb.2019.07.048.