TESTING THE ACCEPTABILITY AND ORGANOLEPTIC QUALITIES OF MULTIPLE MICRONUTRIENT FORTIFIED RICE IN SCHOOL CHILDREN, LAO PDR

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Photo by: WFP Laos

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INTRODUCTION

Vitamin and mineral deficiencies are highly prevalent in low- and middle-income countries including Southeast Asia. Globally, over 50% of children less than 5 years of age and non-pregnant women of reproductive ages have one ore more micronutrient deficiencies (Stevens et al., 2022). However, data on older children is very limited. Food fortification is considered one of the most cost-efficient interventions to increase vitamin and mineral intake and reduce the prevalence of anemia and micronutrient deficiencies (de Benoist and Hurrell, 2006).

For over 20 years, the United Nations World Food Programme (WFP) has been advocating for the inclusion of fortified foods in the food basket it offers. Since 2022, WFP Lao PDR has begun introducing white rice fortified with multiple vitamins and minerals within the school meal programme. This programme, implemented by the Ministry of Education and Sports (MoES), WFP, and partners, offers an opportunity to provide a complete package for nutrition enhancement by introducing nutritious foods, providing nutrition education, and improving Water, Sanitation and Hygiene (WASH) related services within schools. The package addresses the underlying causes of malnutrition as identified in the National Plan of Action on Nutrition (NPAN) 2021-2025.

The WFP school meal programme provides rice fortified with multiple vitamins and minerals (100g dry fortified white rice/child/day), which is procured through the United States Department of Agriculture (USDA). Together with fortified rice, fortified vegetable oil (10g/day, fortified with Vitamins A and D), 40g/day of lentils for three days a week and 30g/day of canned fish, provided two days a week, are purchased through regional procurement. The food ration provides ±630 kilocalories, which is approximately 48 percent of the recommended daily intake for pre-primary school children and between 33 – 42 percent of daily energy (kcal) requirements for primary school children.

Whilst it is known that the addition of vitamins and minerals may alter the organoleptic qualities of food, one of the several success factors of rice fortification is the minimal change in sensory qualities, in addition to micronutrient retention and stability (Saha et al. 2021). Despite this, little is known about the appreciation of the organoleptic qualities (i.e. taste, sight, smell, touch) of fortified rice among the beneficiaries of the Lao school meal programme since its introduction. The successful introduction of fortified rice requires several steps, of which the acceptability and organoleptic qualities or sensory properties of a fortified food is one (figure 1).

The cook at the school in Sangthonng district is preparing steamed-rice to be served during lunchtime.

Photo by: WFP/Lee Sipaseuth

Figure 1: Decision process of food fortification to ensure success

The energetic and enthusiastic schoolchildren at Houypan School in Pak-Ou district, Luang Prabang Province are eagerly lining up for their delicious and nutritious lunch!

Photo by: WFP/Lee Sipaseuth

OBJECTIVES

This study aimed to better understand the changes in organoleptic qualities of rice once fortified, and whether these changes influence its acceptability by the target beneficiaries. The primary objective was to determine whether caregivers (which could either be parents or relatives), teachers, and school children, could differentiate between fortified rice and unfortified/conventional rice. A secondary objective was to determine nutrition knowledge, attitudes, and behaviours towards fortified food products. The former objective was tested through a triangle test in which subjects were asked to whether they could identify differences in taste, appearance, or smell among three bowls of rice. For the latter objective, a short questionnaire was administered and Focus Group Discussions (FGDs) with caregivers and teachers were organized.

Specific objectives:

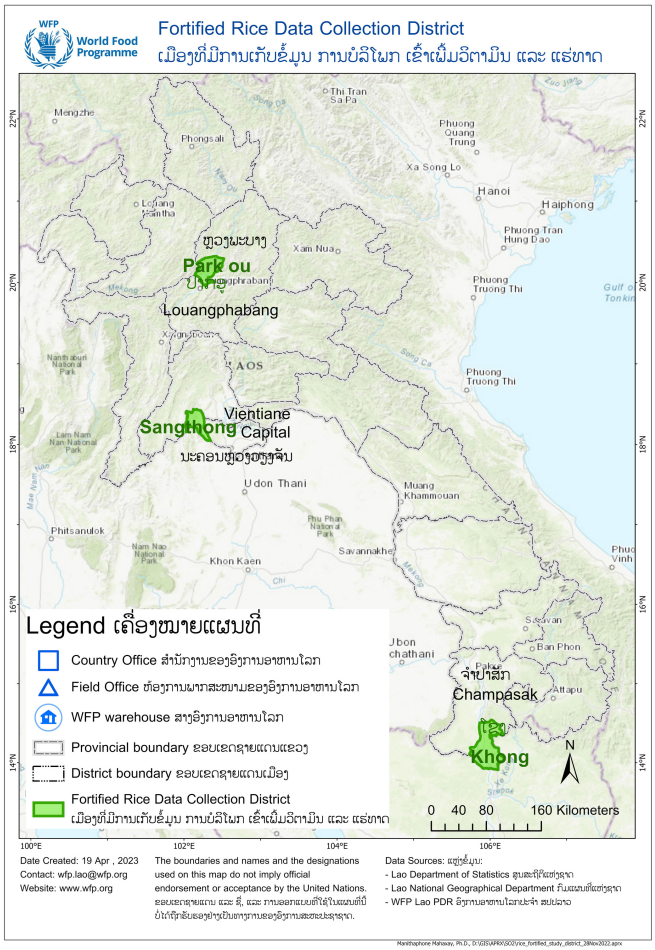
1. To test whether there are any identifiable organoleptic differences between fortified and unfortified/conventional rice (taste test), and overall acceptability of fortified rice among school children, their caregivers, and teachers.
2. To quantitatively assess nutrition knowledge and attitudes towards fortified rice among caregivers, teachers, and local authorities.
3. To qualitatively assess attitudes and perceptions of caregivers, teachers, and village authorities towards fortified rice through several FGDs.

STUDY DESIGN

The study was conducted in six schools in three provinces (two schools per province): Vientiane Capital, Champasak and Luang Prabang Provinces. The selected districts are marked in green on the attached map of Lao PDR. Schools were selected based on a set of criteria, in consultation with the MoES.

The criteria for school selection for the study were:

- Participants of the USDA McGovern Dole school meal programme, in which fortified rice is being provided;
- Schools located in both rural and urban areas, with a majority of students from ethnic villages (Lao Loum, Hmong, Kmu), who commonly consume glutinous or unglutinous rice in their homes;
- Schools that have small food shops around the perimeter of the school; and
- Schools with convenient road access during the rainy season.



Drone on a small community in northern province of Laos

Photo by: WFP/Lee Sipaseuth

INFORMED CONSENT / ETHICS

Ethical approval was obtained from the National Ethic Committee for Health Research (NECHR), number 057/NECHR, dated 29 July 2022. In addition, WFP had prior approval to conduct the study from the MoES and informed consent from caregivers of participating students.

METHODOLOGY

Materials

The acceptability study used USDA imported white rice fortified with eight nutrients: vitamin A (Palmitate), vitamin B1 (Thiamine Mononitrate), vitamin B3 (Niacinamide), vitamin B6 (Pyridoxine Hydrochloride), vitamin B9 (Folic Acid), vitamin B12 (Cyanocobalamin), Iron (Ferric Pyrophosphate) and Zinc (Zinc Oxide). To compare the acceptability of fortified rice with unfortified rice, the study team used local unfortified white rice similar in colour and size to the fortified rice.

Tools and methods

The study used four tools to collect the data. These included the triangle test, taste test, interview questionnaire (survey), and structured focus group discussion.

Triangle test

Caregiver-child pairs and teachers were asked to taste three different bowls of rice. Two (2) of the bowls contained unfortified rice, and one (1) bowl contained fortified rice. Bowls were identical in appearance (white, plastic bowl with plastic spoon), but each bowl was numbered with a quasi-random number (2 or 3 digits). Bowls containing fortified rice contained a “5” as last digit, whereas bowls with unfortified rice contained a “2” as last digit.

Rice was cooked in two different rice cookers, labeled with a number “2” (unfortified rice) or a number “5” (fortified rice). Each parent/child/teacher was asked to taste the rice from the three bowls, which were placed on the table in front of the participant in random order, and to select the one which they perceived was different from the others, or to tell the interviewer if s/he thought there was no difference.

Taste test in Sangthong District, Vientiane Capital

Photo: Maree Bouterakos

When there is no detectable difference between fortified rice and unfortified rice, it is expected that in 33% of the cases, the fortified rice is chosen by chance. If the fortified rice bowl is, however, identified much more often than can be expected by chance, it can be assumed that there are distinguishable differences between unfortified and fortified rice, and these differences need to be explored in the taste test questionnaire and the FGD. The T-test uses a binominal distribution with a 33% possibility to test significant differences.

Taste test

Caregiver-child pairs and teachers were asked to taste two different samples of rice (fortified and unfortified) in succession, in a random order, and fill in a form with questions on organoleptic qualities (taste, smell, appearance, consistency) for each bowl.

Questionnaire

Teachers and caregivers were asked to participate in an interview. The objective was to test: a) basic nutrition knowledge and perceptions on vitamins and minerals, food sources rich in vitamins and and benefits; b) household practices, behaviours and preferences regarding rice preparation and consumption; and c) awareness and acquisition needs of fortified rice. Statistical analysis of data and summarizing of data were done with SPSS (Statistical Package for the Social Sciences) and Excel.

Surveyed data was mainly generated in forms of means and percentages for an entire sample comprising all three study areas. In addition, segregated data for individual study areas was also generated to serve other reporting purposes, including household weekly income and expenditures on foods. These quantitative data were also elaborated in FGDs.

Schoolchildren participated in a triangle test in Pak-Ou district, Luang Prabang Province.

Photo: IRD/Frank

Focus Group Discussion (FGD)

Two FGDs were conducted in each target village. Participants were the same as those in the interview FGDs and were arranged on a convenient basis after the target participants participated in the taste test and the questionnaire. As there were only a small number of teachers per school (3-5), and a few male caregivers, each group was not separated based on gender, nor participant categories. Each group contained between 4-9 members.

The group discussions were facilitated by 2-3 members of the study team, who were tasked with asking pre-designed and probing questions. One member of the study team took notes and the discussion was conducted in Lao language. The discussions were recorded, and scripts were later translated into English by the research supervision team.

Each FGD was facilitated to start the discussions by using a semi-structured questionnaire aiming to gain deeper information in addition to the previous survey. Supplementation was another key topic for the discussions, in addition to basic knowledge on vitamins and/or minerals, fortified foods/rice and its introduction in the school meal programme, as well as future commercialization.

Analysis was made by simple coding and grouping of key themes of the discussions. Final interpretation of the discussions was later made based on themes commonly coded and grouped. Findings were presented on an individual district basis and overall consolidation against the key discussed topics.

Community members participating in the Focus Group Discussion in Sangthong District, Vientiane Capital.

Photo: CRS/Pheng Inthamixay

RESULTS

Population characteristics

In total, data were available for 183 subjects (Table 1). School children (n=80) comprised 48 girls (60%) and 32 boys (40%, P=0.09), whereas for caregivers (n=80), 58 were female (73%) and 22 were male (28%). For teachers (n=23), the distribution was 16 females (70%) and seven males (30%, P=0.093).

Table 1. Distribution of subjects in the 3 provinces

Province	Caregivers	Children	Teachers	Total
Champasak	26	24	8	58
Vientiane	25	20	8	53
Luang Prabang	29	36	7	72
Total	**80**	**80**	**23**	**183**

Triangle Test

Overall, 160 of the 183 subjects thought one bowl of rice was different from the other two bowls. Or, to put it another way, of the 183 subjects, only 23 subjects found no difference between the three bowls of rice and thought the fortified and unfortified rice were indistinguishable. Of these 23 subjects, 20 were school children, two were caregivers and one was a teacher.

Of the 160 subjects who identified one different bowl of rice, 125 subjects (78.1%) picked out the fortified rice as the different rice, a percentage far higher than can be expected by chance (P<0.0001). There was no difference in determining the correct bowl of rice between caregivers (80.8% correct, P<0.001), teachers (81.8%, P<0.001) or school children (73.3%, P<0.001). Of the female subjects, 81% picked out the correct bowl of rice, against 71% of the male subjects (difference not statistically significant).

Schoolchildren participated in a triangle test in Pak-Ou district, Luang Prabang Province.

Photo: IRD/Frank

Schoolchildren participated in a triangle test in Pak-Ou district, Luang Prabang Province.

Photo: IRD/Frank

Please note that an important limitation to the current study was that the rice used to make the fortified rice and the control rice were not of the same type as the fortified rice was blended and purchased from the USA, while the control rice was bought on the local market. Importing unfortified rice from the USA was logistically impossible. Therefore, although it is very well possible that the differences in sensory properties and the higher preference for unfortified rice compared to fortified rice are due to the addition of vitamins and minerals, the current study set-up is unable to give a definite answer on this, and only local blending of locally procured rice with fortified rice kernels, and comparing these two for organoleptic qualities can answer this question.

Taste Test

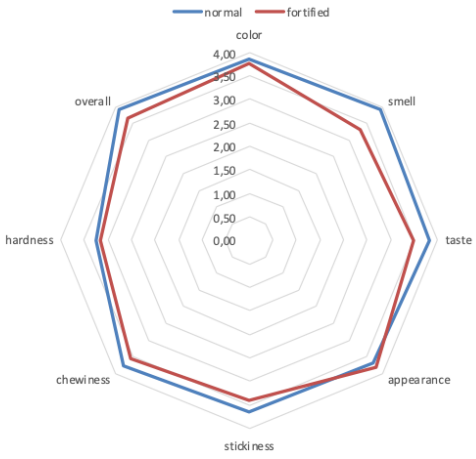
For the taste test, 366 observations on organoleptic qualities were available (183 for fortified rice and 183 for unfortified rice). The average overall score on acceptability for both types of rice combined was 3.8 points or just below "good" (4 points). Similarly, the overall acceptability rate of fortified rice was ranked at normal to good, although it was significantly lower than the acceptability for unfortified rice (3.93 for unfortified rice and 3.66 for fortified rice, P=0.003, Mann-Whitney U test, Table 2). All seven organoleptic qualities of fortified rice were scored normal to good, but for four of the seven different organoleptic qualities (smell, taste, stickiness, and chewiness), unfortified rice scored significantly higher than fortified rice (Table 2). Of concern, almost one out of five subjects (19.9%) scored the smell of fortified rice as "bad" or "not too bad", compared to only 1.1% for unfortified rice. Similarly, 10.5% of subjects scored the taste of fortified rice as "bad" or "not too bad", compared to 6.1% for unfortified rice.

Table 2. Mean scores (range) for organoleptic qualities of fortified rice and unfortified rice.

	Unfortified Rice	Fortified Rice	P value for difference
Color	3.83 (2 – 5)	3.76 (2 – 5)	0.60
Smell	3.94 (2 – 5)	3.31 (1 – 5)	**0.0001**
Taste	3.81 (1 – 5)	3.48 (1 – 5)	**0.0001**
Appearance	3.69 (2 – 5)	3.80 (1 – 5)	0.134
Stickiness	3.64 (1 – 5)	3.41 (1 – 5)	**0.002**
Chewiness	3.76 (2 – 5)	3.43 (2 – 5)	**0.016**
Hardness	3.27 (1 – 5)	3.15 (1 – 5)	0.21
Overall	3.93 (1 – 5)	3.66 (2 – 5)	**0.003**

These differences in organoleptic qualities are also apparent in the radar plot below (Figure 2).

Figure 2 Differences in organoleptic qualities



Survey and FGD

This session presented the combined results of the questionnaire interview and FGDs. There were 103 participants, who were teachers and guardians of students, mostly mothers from six selected villages, of which 82 were also invited to participate in the FGDs, that ranged from 4–9 participants per group. Key findings from the two data collection methods were categorized into three parts, including a) knowledge and perceptions towards vitamins and minerals, b) knowledge and perceptions towards fortified rice, and c) behaviours around rice cooking preparation and consumption which may influence the acceptability to fortified rice.

Part 1: Basic knowledge of the participants and their perceptions toward vitamins and minerals

1.1. Knowledge on vitamins and minerals

FGDs showed that most of the groups across the three districts had a very basic understanding of the concept of vitamins and were not familiar with the term “minerals”. Information came mainly through health information sessions in their community, and during visits to health facilities. A few groups also had gathered information through media sources (TV/radio spots) or even food labels. Most groups were aware of the sources of vitamins and supplements through consumption of different foods and supplements. Surveyed data also found that 71% of correspondents understand they obtain vitamins and minerals by eating a variety of foods, including vegetables, fruits, meat, fish, and eggs.

Overall, the FGD showed that participants in all three provinces were aware of the perceived health benefits of vitamins, such as good health through increased immunity, brain development, good appetite, and quality sleep. However, a few groups raised concerns about possible negative impacts of consuming too many vitamins or due to the chemical residues in vegetables such as becoming over or underweight, tired, dizzy, or having gastrointestinal issues such as diarrhea. Percentages of positive perceptions towards the perceived health benefits of vitamins and minerals as given in the questionnaire are shown in Table 3.

School cook participated in a Taste Test at Sangthong District, Vientiane Capital.

Photo: IRD/Frank

Fortified Rice: Delicious and Nutritious!

Photo: Canva Pro

Table 3: Perceptions toward benefits of vitamins and minerals

Details	Percentage
Heard about vitamins & minerals	77%
...Important to very important to health	63%
...part of daily foods/diets	68%
...good for learning	75%
...good for taste	66%
...good for child growth	77%
...good for energy/strength	73%
...good for skin colour	63%
...good for recovering from illness	68%

However, a few groups knew the benefits and functions of individual vitamins and minerals, specifically vitamins A, B and C. Some groups in Parkou and Sangthong districts could also recall vitamins B12 and B6. Some groups in Parkou and Khong knew calcium and iron, but they did not know that these were minerals. Only one group in Parkou understood the benefits of individual vitamins and minerals, for example, that iodine prevents goitre and anaemia, and that B1 is good for mother and child health.

1.2. Knowledge on supplements

FGDs showed that most groups had limited knowledge about supplements even if they had experienced or thought positively towards them. This was one of the challenges preventing their access to supplements. Other challenges included a lack of money, distance between home and pharmacy, and the unacceptable smell of iron tablets. Key findings are summarized as follows:

- All three districts experienced taking supplements received from doctors/nurses during pregnancy.
- All three districts have positive thoughts about taking supplements, knowing they are beneficial to their health.

Part 2: Knowledge and perceptions towards rice fortification

2.1. Knowledge and perceptions about the health benefits of fortified foods/fortified rice

FGD and the interview found that participants received limited information about fortified foods, resulting in a general lack of knowledge. Most groups were familiar with fortified rice rather than fortified foods. Even though some groups could recall fortified salt, oil, and rice as samples of fortified foods, many of them were still confused in comparison to processed foods and drinks such as noodles, soymilk, and other packaged groceries. This may help explain why there were concerns regarding chemical residues and distrust about the efficacy of fortification.

On the other hand, findings from the interview showed a high percentage of positive attitudes towards fortified rice, although there were still some concerns when it was discussed in FGD.

Table 4 knowledge and attitudes on fortified rice.

Details	Percentage
Knows about fortified rice	54%
Believes that fortified rice is better than unfortified rice	88%
Wants to have fortified rice cooked in school lunches	98%
Wants to cook fortified rice for the family	72%
Wants to cook fortified rice at least two days per week	61%

Details of discussion topics in relation to knowledge, benefits, and concerns for the adverse impact of fortified rice are summarized as follows:

- All three districts had heard of food fortification, in particular, fortified rice through the school meal programme, and also the purpose of food fortification to ensure consumers obtain enough vitamins. However, they were not sure they had the correct information and were interested to know more about food fortification.
- Although all three districts could list the correct names of fortified foods such as rice, oil and salt, some individual groups also misunderstood noodles, canned fish, soybean, water, milk and vegetables as fortified foods. Every group without a teacher as a group members could not define or explain what food fortification was. This indicates the need to educate the target communities to improve their knowledge that only rice and oil are fortified foods that have been introduced in the school meal programme at this time.

With beaming smiles, the school cooks serve up nutritious lunches for the students.

Photo: WFP Laos

Schoolchildren participated in a triangle test in Khong district, Champasak Province.

Photo: WFP Laos

- A majority of the groups across the three districts had more positive thoughts about fortified foods. However, a few groups had concerns about: a lack of knowledge on food fortification among other villagers; the potentially high price of fortified foods; chemical residue on fortified foods; and about possible future impacts of the consumption of fortfied rice.
- Common health concerns raised by some groups in Parkou and Khong districts were around vitamins causing weight gain if taken in excess or not being good for people with high blood pressure. In addition, the groups in Sangthong district felt it was too early to have adequate information about the health benefits of fortified foods given fortified rice had only been introduced in the preivious few months.

2.2. Perceptions toward the introduction of fortified foods in school meals

Overall, the interviewees (teachers and caregivers) had no objection to having fortified rice in their school meal for children given its health benefits with 98% of interviewees expressing support. Importantly, some lessons learnt about fortified rice cooking improvements were shared during the FGDs. Interviewees found that diversified lunch menus and cooking practices helped resolve some of the challenge associated with the smell and taste of fortified rice. Detailed discussions were as follows:

- All three districts had no objections to having fortified rice cooked in the school meal for children, even though a few groups observed that some school children stated they do not like the smell or bland taste of fortified rice.
- The groups in Sangthong shared that the smell and taste issue could be resolved by: a) serving fortified rice with a diversity of meals such as meat, fish, eggs and vegetables; b) cooking fortified rice in different recipes, such as fried rice; and c) steaming fortified rice with more water.

2.3. Future of commercialization of fortified rice

The potential for future commercialization opportunities, was highlighted by both the FDG and the interview. The participants expressed their willingness to buy fortified rice for their household consumption. However, this was conditional on the price of fortified rice being either cheaper or only marginally higher than unfortified rice – for example, no more than about 23% more (which would take the average price at present from LAK 10,000/kg to LAK12,254/kg). Another condition was the rice variety needs to be glutinous. More details of the findings from FGD were as follows:

- A majority of the groups in all three districts would buy fortified rice if it is available in the market, due to its perceived health benefits.
- However, some of the major groups noted this would still be conditional on the price, rice variety, and sensory properties such as softness and taste.
- In addition, there were other suggested changes. For example, a few groups in Khong and Parkou preferred the fortified rice to be glutinous. In addition, a group in the latter district suggested fortified rice should be white with larger kernels. In effect, these are associated with the sensory properties of the unfortified rice as a main mixture of fortified rice.

All three districts believe that other family members and people in their community would eat fortified rice if they were aware of the health benefits. One group in Parkou observed that their children and elders liked fortified rice. Willingness to buy and the acceptable price of fortified rice are quantitatively shown in tables 5 and 6.

Table 5: Willingness to buy fortified rice

Details	Percentage
Willingness to buy fortified rice if no price difference (all districts)	59%
Willingness to buy fortified rice even if a higher price (all districts)	26%

Table 6: Acceptable price of fortified rice

Details	Average
Willingness price of fortified rice (all districts)	**12,254**
Percentage of the price compared to unfortified rice (all districts)	**23%**
Price of fortified rice (Parkou)	*12,100*
Percentage of the price (Parkou)	*21%*
Price of fortified rice (Sangthong)	*12,937*
Percentage of the price (Sangthong)	*29%*
Price of fortified rice (Khong)	*11,970*
Percentage of the price (Khong)	*20%*

DISCUSSION

To our knowledge, this study is the first acceptability study on organoleptic qualities of fortified rice conducted in Laos. The study was conducted in target primary schools of the USDA McGovern-Dole supported School Meal Programme, in three different provinces: Luangprabang, Vientiane Capital and Champasack, with a total of 183 participants, consisting of school children, caregivers, and teachers.

Identification of fortified and unfortified rice

An important finding of the study is that there are significant differences in organoleptic qualities between fortified and unfortified rice, with 68% of participants correctly identifying a bowl of fortified rice out of three bowls of rice, a figure that is higher than can be expected by chance (33.3%). However, although this shows that cooked fortified rice was noticeably different from unfortified rice, it does not indicate a preference for one or the other.

Acceptability

On overall acceptability, participants gave satisfactory scores of "normal" to "good" for both fortified and unfortified rice. This implies that both fortified and unfortified rice were acceptable among the participants, although the latter scored higher on organoleptic qualities. The 0.27 difference between the overall rating score (3.66 vs 3.93 for fortified rice and unfortified rice) was statistically significant, but has likely only minimal consequences in practice, as the average appreciation is still "normal" to "good". The difference found in the present acceptability trial is in line with other studies, reporting for example a difference of 0.4 in scoring between unfortified rice (score of 4) and fortified rice (score of 3.6) (Hussain, Singh and Rather 2014). It is noteworthy that fortified rice sometimes scores higher on organoleptic qualities than unfortified rice, for example in the study by Sarker et al., (2015) who reported a 0.4 higher score for fortified Biryani rice, or in the study from Khanh et al., (2014). The present study also asked the participants to score their acceptability to other sensory properties of both fortified and unfortified rice. Almost all organoleptic properties of unfortified rice had higher scores than that of fortified rice.

Interestingly, there were no statistically significant differences in "colour" or "appearance" scores between fortified and unfortified rice, indicating that fortification does not lead to visual changes. This finding can probably be explained by the type of micronutrients used to produce the fortified rice kernels. Certain micronutrients, such as riboflavin or beta-carotene tend to colour the fortified rice kernels. The study of Beinner et al. (2010) also confirmed the advantage of rice fortification with ferric pyrophosphate in that it did not lead to changes in sensory characteristics of fortified rice such as color, smell, and taste. However, in the present study, we found that smell and taste of fortified rice were significantly different to that of unfortified rice. We do not know which micronutrient(s) cause(s) these organoleptic changes, but there are several candidates. A certain degree of a metallic flavour can be given by zinc, as well as by iron sulfate (FeSO4) (Saha et al. 2021). B-vitamins are also known to affect the smell of fortified rice. Besides micronutrients, the wax used for coating the fortificants on the rice kernels could have caused changes in smell and thus affect the taste of fortified kernels (Alavi et al. 2008).

Two other properties with significantly higher scores for the unfortified rice were stickiness and chewiness. Fortified rice had lower scores for these properties. These differences are unlikely to have been caused by the fortification itself, as the blending rate of fortified kernels with unfortified rice was only one percent. Hence, the likely contributor to the difference in these sensory properties is an inherent difference in the conventional milled rice kernels blended into fortified rice in the USA, in comparison to the unfortified rice "control rice" procured in Lao PDR. The study was unable to justify the importation of unblended (unfortified) rice from the USA as a "control rice" for the study.

From a programme perspective, the normal to good overall acceptability of fortified rice is an important finding, indicating that the introduction of fortified rice within the school meal programme is not likely to impact compliance. Without considering the commercial aspects, introducing fortified rice in the school meal programme, and in other social safety net programmes that address food and nutrition security concerns in Lao PDR, will help close the nutrient gap that currently exists for many vitamins and minerals within the Lao dietary intake. Insights from the FGDs also suggest that these sensory challenges could be resolved by: a) serving the meals with diversified ingredients such as vegetables, meat and eggs; and b) cooking fortified rice with more water to increase the stickiness and chewiness (a systemic review of Pyo, Tsang and Parker (2022) found that adding more water helped starch leaching in cooked fortified rice). A trial conducted in WFP-assisted schools in Timor-Leste, assessed the acceptability of fortified rice when served with beans and vegetables as a side dish (WFP 2020). The results of that trial showed very high percentages of students who liked the taste of both fortified rice and unfortified rice, when mixed with other ingredients. The trial found that 79% of students marked "good" and "very good" to the taste of fortified rice followed by 76% for unfortified rice.

Basic knowledge on vitamins/minerals and fortified foods

While participants knew about vitamins and their sources as well as supplements, very few could recall the functions or benefits of individual vitamins during their participation in the FGD. This finding was similar to another study in four regions with a high prevalence of stunting in Lao PDR which showed that although most ethnic mothers know about vaccination, they did not know about the importance of vaccination during pregnancy and postpartum (Mbuya et al. 2020). From the same study, the percentage of participants who knew at least one reason why "vegetables and fruits" and "animals" are important for the human body was still low in some provinces, including Phongsaly, in northern Laos. For example, 50% for "vegetables and fruits" and 48% for "animals". While the majority of participants in this acceptability study seem to understand the health benefits of vitamins and minerals, when asked if "vitamins and minerals were good for health, for learning and for child growth", there seemed to be discomfort in sharing this knowledge with others in the FGDs.

Fortified foods were not known among the participants, except for fortified rice received through the school meal programme (oil and rice). During the FGDs, most of the groups were confused between fortified foods and other processed foods. They believed that all noodles, milk, soy sauce, vegetable oils sold in their community were fortified, while only fortified oil and fortified rice had recently been introduced and only in the schools. Although this acceptability study found that 88% of the interviewees believed that fortified rice was better than unfortified rice, FGD findings showed that their confidence about the benefits of fortified rice was still uncertain, as they had just tried it and were eager to see the results once more time had passed. This suggests that continuing the implementation of the school lunch programme with fortified rice to allow students to have a longer experience in consuming fortified rice/fortified foods, is warranted. This would also support a study on efficacy and enable the documentation of additional evidence.

Some participants had concerns about the side-effects of taking excessive doses of vitamins through fortified rice. They believed that taking too many vitamins would result in gaining weight, becoming dizzy or that it could be poisonous. They indicated that they need to have more information on the basic facts and benefits of vitamins and minerals and fortified foods, especially fortified rice and oil distributed through the school meal programme. This will help create a better understanding among the target community

and a more positive attitude towards their acceptability, although they expressed no objections to having fortified rice cooked in the school meal for their children. Providing basic knowledge on nutritional intake and the benefits of vitamins and minerals in fortified foods to increase the uptake among target consumers, has also been a recommendation from other studies, even in the areas where vitamin/mineral fortified foods and supplements had a higher percentage of use and positive perceptions, such as in Japan (Chiba, Tanemura and Nishijima 2022; 2021). For example, the knowledge context of the study in Japan was that due to nutrient labeling being only voluntary, it was not commonly practised among fortified food producers. This resulted in a lack of knowledge leading to more than half of the participants of the survey not knowing whether they had sufficient intake of individual vitamins (Chiba, Tanemura and Nishijima 2021).

Perceptions toward fortified rice introduced in the school meal programme

Overall, the participants had positive thoughts about fortified rice. 98% of interviewees supported the introduction of fortified rice in the school meal programme due to the health benefits for their children. Other studies have also found that the health benefits of vitamins and minerals is a key factor in why people are motivated to buy vitamin/mineral-fortified foods (Chiba, Tanemura and Nishijima 2022; 2021). The health benefits should be one of the key messages delivered to the target school children, teachers, and the wider community.

In addition to the health benefits of fortified rice, participants expressed their appreciation for the school meal programme, noting the benefits of not only knowing their children are having a nutritious lunch each day, but knowing they are safe at school with time to play and study during their lunch break. From the perspective of sustainability, it is crucial that parents and the community find school meals beneficial, as it provides strong justification to seek their support to the programme by contributing additional vegetables, fruits, meat, fish, eggs to ensure nutritious and diverse meals. This not only helps to meet the nutrient requirements of school children, but also improves the overall taste and smell of fortified rice.

Perceptions toward commercialization of fortified rice

In terms of further commercialization of fortified rice, more than 80% of the interviewees answered that they would buy fortified rice when it was available in the market. However, only 26% showed a willingness to buy if the price of fortified rice is higher than unfortified rice. The average acceptable higher price was 23% more than the base price (currently LAK10,000/kg) of unfortified rice. This price constraint was also a key factor affecting the decision to buy fortified foods among people in higher economic countries, such as Japan (Chiba, Tanemura and Nishijima 2021). The recommendation to relevant stakeholders is to consider reducing the economic barrier to the implementation of fortified foods, which could be applied to the Lao context. However, it is too early to confirm a commercialization opportunity of fortified rice in rural communities in Lao PDR. It is important to note that most of Lao rural families are rice self-sufficient and favor consumption from their own rice field (WFP 2017). Over 65% of the interviewees noted that their rice source for consumption was from their own fields.

LIMITATION OF THE STUDY

One key challenge of the study was to find the an unfortified rice on the local market that was comparable to the fortified rice imported from USA. The team had minimal information on the rice variety or on the year of harvest of the conventional rice mixed in the fortified rice. Therefore, the study team tried to find unfortified rice in a local market in Vientiane Capital, Lao PDR that was similarity in colour, kernel shape and overall appearance to the imported fortified rice as the unfortified rice for the study. However, the team has no information on the quality of other sensory properties of the unfortified rice, such as softness, stickiness and taste. The quality of these properties often depends on different factors such as rice variety, production season and storage duration after milling. To really answer the question on whether the addition of vitamins and minerals to rice changes the organoleptic qualities of the rice, local blending of locally procured rice, and testing the unfortified and fortified rice for organoleptic qualities is needed. This can be done in the near future, when local blending of fortified rice kernels with locally procured rice is tested.

CONCLUSIONS

This study provided important data on the acceptability of fortified rice among school children, their caregivers, and teachers in six schools in three target provinces receiving McGovern-Dole supported school meals in Lao PDR. Fortified rice was accepted at a satisfactory score ranging from “normal to good”, even though organoleptic qualities were clearly distinct from unfortified rice. The differences in the quality of sensory properties between fortified rice and unfortified rice may be due to the fact that the unfortified rice was bought on a local wet market, resulting in fresh rice, which often has more taste. The sensory differences of the fortified rice do not seem to have major impact of the consumption preference of the subjects.

Most participants (98%) showed their support to continue using fortified rice for the school meal programme.

To help deliver a successful school meal programme with fortified rice, this study offers insights on the management of the programme to its stakeholders. Information on the nutrient content of fortified rice, intake, and its benefits, should be disseminated to target school children, teachers, caregivers, and village authorities. Providing adequate information may help reduce any concerns of the target populations regarding perceived side-effects from the consumption of excessive vitamins and minerals through fortified foods. Knowledge of the various health benefits of fortified foods would encourage the consumption of fortified rice among the target populations, and overcome any issues regarding the sensory properties of fortified rice such as smell, taste and softness to chew.

Furthermore, providing cooking and preparation guides for fortified rice might help address some aspects of the organoleptic quality of fortified rice, such as stickiness and softness. For example, fortified rice becomes softer when additional water is used in its preparation.

Another recommendation to address the sensory challenges is to serve fortified rice with diversified food items such as vegetables, and meat, fish and eggs. This may require joint efforts and contributions from the community to supply these foods. Similarly, this joint contribution may need to be expanded to other available nutrition sensitive agricultural projects who may promote/support community-based vegetable gardens and livestock.

To provide the evidence of the various health implications of fortified rice, continuing the provision of fortified rice and fortified foods in the school meal programme is warranted, and an associated efficacy impact study should be conducted.

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