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Development of nutrition-supplemented instant riceberry combat ration from agricultural products of Thaharn-Phandee project

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ABSTRACT

A proposal was put out to develop a novel personal combat ration for the Royal Thai Army (RTA), designed to expedite the cooking process in battlefield conditions. The formulated ration consisted of riceberry combined with vegetables sourced from the Thahan-Phandee project at Chulachomklao Royal Military Academy (CRMA), aiming to deliver vital nutrients to soldiers. The ration processing was optimized based on using affordable RTA's equipment and resources. Firstly, the riceberry was soaked and preheated in 0.05% sodium phosphate at 70 °C for 20 min, then boiled for 12 min. Later, the riceberry was dried at 80°C until the moisture content reached below 7%. The rice was subsequently combined with pre-prepared dehydrated vegetables, including fairy mushrooms (oyster mushrooms), gourds, baby corn, basil leaves, and long beans. These mixtures were then packed into vacuum-sealed bags, with each package containing 200 g. This portion size provided energy for a single meal, totaling 722 kcal. Cooked rice could be obtained by rehydrating it with hot water and allowing it to sit for 7.5–10 min. Ninety-four cadets were selected as the sample for conducting a sensory examination. Regarding taste, the product exhibited a considerably higher score than conventionally cooked white rice and riceberry ($P < 0.05$). However, no substantial difference was observed in appearance, texture, flavor, and acceptability score. The product had a positive reception from cadets for its use during their field training activities, as their ratings fell under the "very satisfied" category.

Keywords: instant rice, riceberry, personal combat ration, Thaharn-Phandee project

INTRODUCTION

Providing adequate rations is crucial for sustaining the physical well-being and motivation of soldiers on the battlefield. The significance of the ration lies in its provision of energy, nutrition, and overall satisfaction for soldiers. In certain instances, military operations may encounter constraints in the logistical aspect of food supply, primarily attributable to the obstruction of transport routes by hostile forces or natural barriers. Hence, the soldier's ability to establish communication with ration delivery units is unattainable. Military units often require specialized sustenance that can be conveniently transported to the field, commonly called a "personal combat ration" or "portable ration," to ensure survival. This ration may consist of quick, canned, or Meal Ready to Eat (MRE). The latter refers to a self-contained individual ration that the United States Army utilizes. This product is designed for utilization in situations where alternative food sources are not accessible. The MRE is a type of food that does not require any preparation and is often formulated to provide soldiers with sufficient daily energy and nutrients (Mason et al., 1982). Nevertheless, the Royal Thai Army (RTA) still lacks an understanding of formulating and advancing a suitable individual combat ration for Thai soldiers. Currently, the rations manufactured by the RTA predominantly consist of canned food, typically accompanied by uncooked white rice (Quartermaster Department, 2020). Hence, the nutritional content may be inadequate regarding essential vitamins, minerals, and dietary fibers. Furthermore, using dried rice as personal fighting provisions is impractical due to the prolonged heating duration required.

Instant rice, also known as semi-cooked rice, is a type of rice that undergoes partial precooking before being dehydrated to achieve a dried state. This instant rice resembles uncooked rice and can be preserved for extended periods at room temperature. Instant rice can be prepared or rehydrated more rapidly than uncooked rice by introducing hot or boiling water and allowing it to sit for 5–10 min. When comparing the cooking time of dry rice, it is evident that instant rice significantly reduces the required duration to prepare a meal,

taking considerably less than 30 min. This characteristic makes instant rice viable for individuals seeking a quick and convenient solution, particularly suitable for personal battle rations. Various techniques can be employed to produce instant rice, including soak-boil and dry, freeze-drying, chemical treatment, or utilization of microwave radiation (Suksomboon and Limrungrueangrat, 2019). The former approach is often utilized for preparing instant rice due to its cost-effectiveness and simple procedure. Pimpilai (2006) used this method to produce instant brown rice. The most suitable conditions were soaking rice in water at 50°C for 30 min, steam heating at 121°C for 2 min, and then drying in a hot air oven at 80°C for 60 min. Obeta et al. (2019) proposed three methods for cooking instant white rice, i.e., boiling, fissuring, and pressing-drying. The sensory evaluation result showed that the instant rice obtained by the boiling-drying method had the highest level of acceptance. The procedure involved boiling ice at a temperature range of 100−105°C for 12 min. Subsequently, the rice was frozen for 24 h, then oven drying at 50°C.

The Thaharn-Pandee (Good Soldier) project refers to the agricultural farming region in nearly every military unit around Thailand. This project is being implemented by the "self-sufficiency economy philosophy" of H.M. King Bhumibol Adulyadej the Great. It encompasses practices such as natural agriculture and organic farming, specifically targeting soldiers and their families. To mitigate costs and augment household revenue, individuals can cultivate food that is safe for consumption and suitable for commercialization. Additionally, the establishment serves as an educational hub for farmers and individuals residing in the surrounding area. The Thahan-Pandee project boasts a diverse range of agricultural products, including several types of rice, such as jasmine, brown, and riceberry, and various vegetables, such as mushrooms, squashes, herbs, crops, and beans. Hence, this particular sector within the military unit holds the potential as an optimal location for procuring essential resources that may be subsequently utilized to produce personal battle rations.

Riceberry, scientifically known as *Oryza sativa*, is a rice cultivar from Thailand. It results from a hybridization process involving Jao Hom Nin, a locally grown purple rice, and Khao Dawk Mali 105, a variety of Jasmine rice. Its primary objective is to enhance rice's nutritional composition, aromatic properties, and palatability. Riceberry possesses a notable array of minerals, including fiber, iron, anthocyanin, beta-carotene, and other vitamins (Vanavichit, 2020). Khuenpet et al. (2020) investigated various drying techniques and formulated an instant rice porridge enriched with nutritional fiber. The types of rice utilized in this context encompass broken riceberry, -jasmine rice, and -sticky rice. The sensory test results indicated that the broken-riceberry porridge received the highest rating in terms of customer acceptability. Niyomwet et al. (2018) examined and put forth a production methodology for instant broken-riceberry porridge that incorporates dehydrated chicken and various dried veggies. According to their report, the composition of the porridge (referred to as the porridge formula) and the quantity of seasoning powder included in the formula were found to impact consumer satisfaction. Nevertheless, Thai individuals prefer to eat cooked rice over porridge. The cooked rice has the potential to be paired with various side dishes or curries, so offering a diverse range of menu options. Therefore, preparing the ration in the form of instant whole riceberry rather than as porridge is more appropriate. However, there is currently no existing documentation on the process of quick riceberry, particularly about its suitability as a ration for military applications.

This study aimed to develop and process agricultural goods derived from the Thaharn-Phandee project in CRMA, specifically riceberry and a variety of vegetables, to develop a novel personal combat ration. The researchers opted for a cost-effective technology, along with tools and equipment accessible for use in RTA. The ration has been formulated to serve as a quick-cooking instant rice option. Additionally, the use of veggies serves to enhance the nutritional content. The primary objective of the product design is to provide sufficient energy to support the everyday activities of Thai soldiers. The sensory evaluation conducted by CRMA cadets involves assessing the meal's taste, texture, and flavor. Furthermore, evaluating packing design and usability in field training is essential to get the most optimal personal combat ration for RTA.

MATERIALS AND METHODS

Raw material

Riceberry rice and vegetables from the Thaharn-Phandee project in CRMA were utilized as raw materials for the ration. Vegetables included fairy mushrooms (oyster mushrooms), gourds (Thai zucchini), baby corn, Thai holy basil leaves, and long beans.

Optimization of instant riceberry processing

The instant riceberry processing was modified from the soak-boil and dry process of instant white or brown rice reported by Laohasawat

and Binchai (1997), Pimpilai (2006), and Obeta et al. (2019) to fit our resources and equipment. The process was optimized and adapted to maximize product quality, including the temperatures and sodium phosphate concentrations used for soaking rice and the temperature for drying rice. Each experiment was conducted in three replications.

Soaking and preheating. In this study, dry riceberry was soaked (at 1:5 by weight) in water or a sodium phosphate solution at a concentration of 0.05 and 0.1% w/v and heated for 20 min at temperatures of 50, 70, or 90°C, respectively.

Cooking. Riceberry was boiled in 0.05% w/v sodium phosphate at 100°C for 12 min. It was then immediately immersed in 3–5°C cold water for 30 seconds.

Drying. Spread the boiled rice thinly on a silicone baking sheet on a steel griddle. Dry rice in a 1500 W hot air oven until moisture content is below 7% (%wet basis, wb). Rice moisture was measured periodically using a food moisture meter. Here, the relationship between the drying temperature at 50, 65, 80, and 90°C, respectively, and the drying time was studied.

Dried vegetables preparation

The dry vegetable was prepared according to Niyomwet et al. (2018). Vegetables (except Thai holy basil leaves) were cut into bite-sized pieces approximately $0.5 \times 0.5 \times 0.5$ cm^3 and boiled at 100 °C for 10 min. At 70°C, all vegetables were dried in an oven with heated air until their moisture content was below 7% (%wb).

Product formulation and packaging. Dried riceberry and vegetables were mixed, and spice powder was added. One ration packaging consists of 150 g instant riceberry (75%), 10 g dry fairy mushroom (5%), 9 g dry gourd (4.5%), 9 g dry baby corn (4.5%), 9 g dry Thai holy basil leaf (4.5%), 9 g dry long bean (4.5%), and 4 g seasoning powder (2%). A vacuum sealer sealed a totaling 200 g of ration in a 20×30 cm^2 bag.

Product rehydration

Product rehydration process. Rehydrating the product to a cooked (ready-to-eat) state requires adding boiling water to the instant ration in a volume equivalent to twice the weight of the rice (or 400 mL). This process should take approximately 7.5–10 min.

Product rehydration ratio and rehydration time. The rehydration ratio (RR) was measured following the method of Prasert and Suwannaporn (2009), where 200 mL of boiled water at 100°C was added to 20 g of instant ration samples. Excess water was drained. The samples were weighed every one minute for twenty minutes. The rehydration time was determined when the RR value was close to one, according to Phukasmas and Songsermpong (2019). RR was calculated thus:

$$\text{Rehydration ratio (RR)} = \frac{\text{Weight of rehydrated product (g)} - \text{Starting dry weight (g)}}{\text{Starting dry weight (g)}}$$

Sensory evaluation and field utility evaluation

Population and sample. A total of 1,490 CRMA cadets comprised the population for this investigation. The sampling process was conducted utilizing Taro Yamane's procedure, which stipulates a confidence level of 95% and a precision level of 10% (Yamane, 1973). Thus, the examination results might indicate the satisfaction of every cadet as a whole. The computation is given below:

$$n = \frac{N}{1 + Ne^2}$$

n is the sample size

N is the population size

e is the precision level, which is 0.10.

When substituting the values, we get the appropriate sample size, which is as follows:

$$n = \frac{1490}{1 + 1490\,(0.10)^2}$$
$$n = 94$$

Sensory evaluation. A total of 94 cadets were requested to taste three rice samples: 1) conventionally cooked white rice, 2) conventionally cooked riceberry, and 3) nutrition-supplemented instant riceberry ration (the experiment product). The conventionally cooked white rice and riceberry were prepared using a 750 W cooking pot, and the weight of rice and water was 1:2.

A total of five sensory parameters were assessed: 1) appearance, 2) flavor (fragrance),

3) taste, 4) texture, and 5) overall acceptability. Acceptability of the products was scored using a 5-point hedonic scale with five favorable score rankings: 1) very unsatisfied, 2) unsatisfied, 3) neutral, 4) satisfied, and 5) very satisfied, ranking from lowest to highest, respectively. The data were subjected to Analysis of Variance (ANOVA) with a 95% confidence level ($P \leq 0.05$). By comparing the significant differences, Duncan's new multiple range test was employed.

Utility in battlefield evaluation. Participants (94 cadets) were asked to evaluate the characteristics of the finished product in an actual field training situation in CRMA. Each cadet was given a product package accompanied by canned garlic meat from RTA's Quartermaster Department to perform the rehydration process by themselves. The evaluated characteristics were as follows: 1) package appearance, 2) quantity of rice per package, 3) portability, 4) rice rehydration simplicity, and 5) suitability for consumption with RTA's canned garlic meat. Five favorable score rankings exist: 1) very unsatisfied, 2) unsatisfied, 3) neutral, 4) satisfied, and 5) very satisfied, ranking from lowest to highest, respectively.

Moisture content and water activity analysis

The product's moisture content (% wet basis, wb) was measured using the AOAC (2000) method. Water activity (aw) was measured using a water activity analyzer (Aqualab, USA).

Proximate analysis of the finished products

Proximate analysis of the dried vegetable-supplemented instant riceberry ration was determined according to AOAC (2000), i.e., moisture, lipids, ash, protein, fiber, carbohydrate, and energy.

Energy and nutrition calculation

The energy and nutrient contents of the product were determined through the utilization of databases acquired from Vanavichit (2020) and the software program INMUCAL (Mahidol University, Thailand), which serves as the benchmark for nutrient intake calculations in Thai cuisine (Institute of Nutrition, Mahidol University, 2015).

RESULTS AND DISCUSSION

Process optimization of instant riceberry

The study employed the soak-boil-dry method (Suksomboon and Limrungrueangrat, 2019) to generate instant rations. The aforementioned procedure comprised three distinct stages: preheating and soaking, cooking, and dehydrating. This research observed process parameters influenced by the instant riceberry quality during the preheating and soaking stage, i.e., soaking temperature and soaking solution concentration, and the dehydrating stage, i.e., drying temperature.

Soaking solution concentration and soaking temperature. The use of stabilizers, such as sodium phosphate, at the appropriate concentration during rice soaking aids in the absorption of water by rice grains, preventing fracturing after drying (Pimpilai, 2006). The experimental result showed that rice soaking in sodium phosphate solution (both 0.05 and 0.1% w/v) outperformed the water in grain breakage reduction (Table 1). In addition, it has been reported that rice grains soaked at high temperatures and then desiccated are more resistant to breakage because the grains swell when exposed to high temperatures during soaking (Laohasawat and Binchai, 1997). The high soaking temperature (70 or 90°C) improved grain breakage prevention. More than 70% of rice grains broke was observed after cooking and drying when the rice was soaked in water at 50°C (Table 1). However, high temperatures (90°C) can cause rice in the bottom of the container to burn (data not shown). It also required more energy and hence was unsuitable for production use. The experiment found that soaking rice at 70°C with 0.05% w/v sodium phosphate resulted in less than 5% fragmented grains. A larger sodium phosphate concentration had comparable results, with less than 5% of broken grains observed (Table 1).

Table 1. Effects of temperature and solution used in the rice preheating and soaking steps on the appearance of rice grains after being cooked and dried

Temperature (ºC)	Water or solution used for soaking	Percent of fractured rice grains after boiling and drying*
50	Water	>70% of total grains
	0.05% w/v sodium phosphate	About 50% of total grains
	0.1% w/v sodium phosphate	10–30% of total grains
70	Water	10–30% of total grains
	0.05% w/v sodium phosphate	<5% of total grains
	0.1% w/v sodium phosphate	<5% of total grains
90	Water	10–30% of total grains
	0.05% w/v sodium phosphate	<5% of total grains
	0.1% w/v sodium phosphate	<5% of total grains

* Data obtained by eye observation.

Drying temperature. After the preheating and soaking steps, the riceberry was boiled for 12 min at 100°C. This cooking stage causes the rice grains to gelatinize and enlarge (Obeta et al., 2019). In the third step, the cooked riceberry was dried in a heated air oven until its moisture content was below 7%. In this experiment, various drying temperatures, i.e., 50, 65, 80, and 90°C, were studied, and the results are shown in Figure 1. It was found that drying at a temperature of 90°C and 80°C required a drying time of approximately 3 and 3.5 h, respectively, to reduce the moisture content of the riceberry to 7% (Figure 1). Considering a household-level hot air oven, the temperature can generally be adjusted to a maximum of 90°C. Therefore, using a temperature of 80°C is a better way to save energy and preserve the use of the oven. Additionally, the drying time is influenced by the density of the rice spread out on the tray; for instance, a thinner layer of rice can result in a shorter drying period.

In summary, the optimal condition was soaked riceberry in 0.05% w/w sodium phosphate heated at 70°C for 20 min, then boiled at 100°C for 12 min. Lastly, dry rice at 80°C for 3.5 h until moisture content is below 7%.

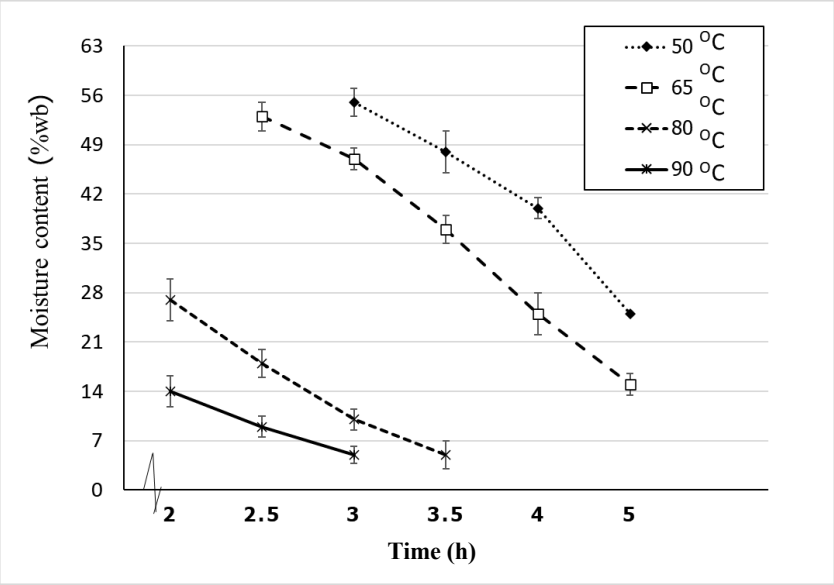

Figure 1. The relationship between the drying time and the rice moisture content at various drying temperatures.

Finished product and its functional properties

Product formulation and packaging. In addition to instant riceberry, dried vegetables such as fairy mushrooms, gourds, baby corn, Thai holy basil leaves, and long beans were added. The powdered seasoning was incorporated into the ration to enhance flavor and taste. The instant ration was vacuum-sealed in a container containing 200 g per package for long-term storage (Figure 2).

Figure 2. Instant nutrition-supplemented riceberry ration in a vacuum-sealed package.

Moisture content and water activity. Our ration exhibited a moisture content of 5.18 ± 0.13% wb and water activity (a_w) of 0.31 ± 0.06. As per the Thai Industrial Standards, the moisture content of instant rice porridge must be below 7% water to ensure its quality is maintained (TISI. 315/2005, Thailand Industrial Standards Institute, 2005). Additionally, a_w value is an important factor in predicting the shelf life of food. When food has an aw less than 0.6, all microorganisms will stop growing. Packaged in airtight containers, the food can be stored for 1 to 2 years (Khuenpet et al., 2020).

Ration rehydration. The rehydration curves of the instant ration are presented in Figure 3. The rehydration ratio (RR) increased with the rehydration time. Phukasmas and Songsermpong (2019) reported that when the RR of instant jasmine rice was close to 1, the rice grains individually separated, and its appearance was similar to freshly cooked rice. The optimal rehydration time of the reported instant rice was approximately 3 to 5 min (Phukasmas and Songsermpong, 2019). The RR of our product was approximately 1 when the rehydration time was about 7.5 min, as shown in Figure 3. The longer rehydration time may result from the type of rice and dried vegetables added.

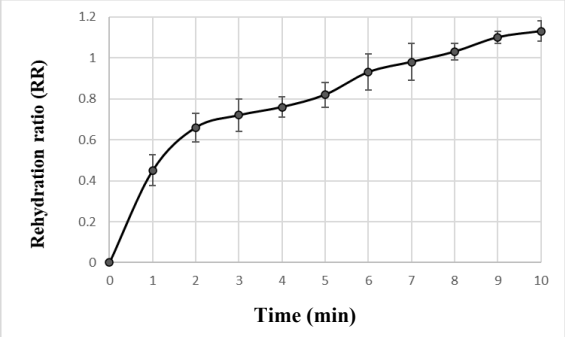

Figure 3. Rehydration ratio of dry vegetable-supplemented instant riceberry ration.

Energy and nutrition

Proximate analysis result. It was found that the dry vegetable-supplemented instant riceberry ration had the following amounts: 5.18 ± 0.15% for moisture, 12.43 ± 0.07% for protein, 2.42 ± 0.01% for ash, 1.41 ± 0.02% for fat, 6.24 ± 0.02% for crude fiber, and 72.32 ± 0.21% for carbohydrates. The ration gave energy of 361 kcal/100 g of the ration. Considering per product container (200 g), the created ration yielded 722 kcal of energy, 24.86 g of protein, and 12.48 g of crude fiber (Table 2).

A single container contains one meal. The total energy the ration provides when soldiers consume three packages daily is 2,166 kcal (722 × 3). By supplementing with 210 kcal/can of canned garlic meat from RTA (Quartermaster Department, 2020), a soldier can obtain a daily energy total of 2,796 kcal (2,166 + (210 × 3)). The aforementioned quantity of energy satisfies the RTA regulation stipulating that personnel must consume a minimum of 2,400 kcal per day (Logistics Department, 2021). This is also comparable to the daily energy expenditure of American soldiers, which McAdam et al. (2018) estimated to be 2,466 kcal.

The National Academy of Medicine of the United States currently advises adult men (ages 19–50) to consume 56 g of protein daily (Institute of Medicine, 2005); individuals who are physically active or athletes may require an additional 84 g (Lemon, 2000). The protein 74.58 g (24.86 × 3) is provided daily in the ration, which is a substantial quantity of protein. It is essential to acknowledge that soldiers are expected to supplement their instant rice ration with canned food or a side dish to obtain the remaining protein. The ration also contains 37.44 g (12.48 × 3) of crude fiber. To determine the value of total dietary fiber in the ration, the nutrient calculation based on the existing database is considered and demonstrated in the next section.

Computational based result. To gain further insight into the ration's essential nutrients, including dietary fiber and necessary micronutrients, a database of Thai cuisine's nutrients, INMUCAL, was employed for computational analysis. The calculated result is shown in Table 2. The calculated energy and protein were close to the measured results from the proximate analysis, which implied that the calculated values were considerably precise. Adult males should consume 38 g of dietary fiber daily (Institute of Medicine, 2005). The computed dietary fiber in the ration was 14.4 g per package, resulting in a total of 43.2 g per day, exceeding the recommended dietary fiber. In addition, based on the database of each ration's ingredient, it was revealed that the ration contains essential micronutrients such as anthocyanin, vitamin A, vitamin C, and beta-carotene. These nutrients help soldiers preserve their physical condition, immune system, and overall health on the battlefield (Lemon, 2000).

Table 2. Dried vegetable-supplemented instant riceberry ration composition with the calculated energy, protein, dietary fiber values, and selected micronutrients based on the INMUCAL database

Items	Amount (g/package)	Energy (kcal)	Protein (g)	Dietary fiber (g)	Important micronutrient(s)
Instant riceberry	150	585	12.0	6.0	Vitamin E, A, anthocyanin
Dried fairy mushroom	10	30	2.1	1.3	Riboflavin
Dried gourd	9	27	1.3	0.9	Vitamin A, C, beta-carotene
Dried baby corn	9	35	2.6	2.4	Vitamin A, C
Dried Thai holy basil leaf	9	23	1.6	2.1	Vitamin A, C, beta-carotene
Dried long bean	9	30	2.6	1.7	Vitamin A, beta-carotene
Total	200◊	730	22.2	14.4	
		(722)*	(24.86)*	(12.48)**	

The net weight also includes 4 g of seasoning powder, which is not shown in the table.
*The value gained from proximate analysis.
**Crude fiber value gained by proximate analysis.

Sensory evaluation and utility in battlefield evaluation

Sensory evaluation. A total of 94 cadets was requested to taste three rice samples: 1) cooked white rice 2) cooked riceberry and 3) nutrition-supplemented instant riceberry ration (the experiment product). According to the findings, consumer satisfaction with the ration fell within the "satisfied" range across all dimensions. The appearance, flavor, texture, and acceptability scores did not differ significantly among the three rice samples. However, concerning gustatory perception (taste), the ration received a considerably higher score ($P \leq 0.05$) (Table 3). The significantly higher scores in terms of taste could result from added vegetables and seasoning. Additionally, it was worth noting that the marginally lower texture score of our product compared to conventionally cooked white rice might be the riceberry's greater hardness than white rice. However, the scores for preference were comparable (or very close) to those for conventionally prepared riceberry, and the ratio indicated that the texture of the riceberry was not impacted by the instant rice processing method (Table 3).

Utility in battlefield evaluation. Ninety-four cadets were also queried regarding the parameters detailed in Table 4. Each cadet was given a product package accompanied by canned garlic meat from RTA's Quartermaster Department to perform the rehydration process independently. Overall, the evaluation results for our product and packaging placed them in the "very satisfied" range, indicating they are suitable for cadets' field training.

Table 3. Sensory evaluation results of 3 rice samples by 94 cadets of CRMA

Parameters	Common cooked white rice	Common cooked riceberry	Nutrition-supplemented instant riceberry ration
Appearance	4.5 ± 0.7	4.2 ± 0.6	4.3 ± 0.4
Flavor (Fragrance)	4.1 ± 0.6	4.0 ± 0.5	4.4 ± 0.5
Taste	3.8 ± 0.3[a]	3.7 ± 0.5[a]	4.4 ± 0.4[b]
Texture	4.2 ± 0.5	3.9 ± 0.5	3.8 ± 0.6
Acceptability	4.1 ± 0.5	3.9 ± 0.5	4.0 ± 0.7

The score ranges from 1 (very unsatisfied) to 5 (very satisfied).
Different superscripts in the same row show a significant difference ($P \leq 0.05$).

Table 4. Results of utility in the battlefield assessment by 94 CRMA cadets

Parameters	Score
Package appearance	4.5 ± 0.3
Quantity of rice per package	4.7 ± 0.4
Portability	4.6 ± 0.4
Rice rehydration simplicity	4.5 ± 0.2
Suitability for consuming with RTA's canned garlic meat	4.6 ± 0.5

* The score ranges from 1 (very unsatisfied) to 5 (very satisfied).

CONCLUSIONS

This article proposes a "nutrition-supplemented instant riceberry ration" as a novel personal combat ration for RTA. The Thaharn-Phandee project, present in each military unit, provides convenient access to the raw materials required for the ration. Furthermore, the ration can be manufactured through a straightforward procedure that utilizes the RTA's capabilities. The optimized condition reported in this study can be employed to produce this ration with satisfactory quality. The preparation time for this instant ration is reduced compared to the current combat ration of the RTA. Additionally, it provides a significant amount of nutrients and energy for the daily activities of Thai soldiers and is compatible with RTA's tinned garlic meat. The vacuum packaging offers advantages in terms of portability. In regards to appearance, flavor, taste, texture, and acceptability, our product satisfies cadets. Furthermore, the product meets the requirements to function as a personal combat ration during the field training of cadets. Subsequently, the researcher intends to enhance the nutritional value of the provisions by incorporating dried meat and creating a ready-to-eat curry that the proposed ration can accompany.

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REFERENCES

AOAC. 2000. Official methods of analysis, 17th ed. Association of Official Analytical Chemists, Washington, DC.

Institute of Medicine. 2005. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. National Academies Press, Washington, D.C.

Institute of Nutrition, Mahidol University. 2015. Food composition database NDI for INMUCAL Program. Mahidol University, Nakhon Pathom. www.inmu2 . mahidol.ac.th. (retrieved October 20, 2023).

Khuenphet, K., Phonpuet, R., Leewanitchayakul, K., and Kaweekhieo, S. 2020. Effect of different rice varieties and drying methods on the quality of instant riceberry porridge fortified with Jerusalem artichoke. TSTJ. 28(10): 1814–1833.

Laohasawat, K., and Binchai, W. 1997. Instant rice production technology, Research report, Biological Sciences Division, Department of Science Service.

Lemon, P.W. 2000. Beyond the zone: protein needs of active individuals. J. Am. Coll. Nutr. 19(5): 513–521.

Logistics Department. 2021. Logistics department letter No. 0404/3970, 30 November 2021: Request to improve and develop guidelines of providing meals for active-duty soldiers. Logistics Department, Royal Thai Army, Thailand.

Mason, V.C., Meyer, A.V., and Klicka, M.V., 1982. Summary of operational rations natick. U.S. Army Natick Research and Development Laboratory Technical Report TR-82/013.

McAdam, J., McGinnis, K., Ory, R., Young, K., Frugé, A., Roberts, M., and Sefton, J., 2018. Estimation of energy balance and training volume during army initial entry training, Int. Soc. Sports Nutr. 15(55). https://doi.org/10.1186/s12970-018-0262-7.

Niyomwet, P., Sappasit, P., Varee, A., and Kongsit P. 2018. Product development of the instant riceberry porridge. Burapha Sci. J. 23(3): 1638–1654.

Obeta, N.A., Ukom, A.N., and Ossai. 2019. Production and quality evaluation of instant rice from three local rice varieties in Ebonyi State. Asian J. Appl. Sci. 12: 52–60.

Phukasmas, P., and Songsermpong, S. 2019. Instant rice process development: Effect of rice cooking methods on the quality of jasmine instant rice dried by industrial microwave oven. J. Microbiol. Biotechnol. Food Sci. 9(2): 330–334.

Pimpillai, S. 2006. Study of the production process of quick-cooking red jasmine rice, Research report. Faculty of Engineering and Agro-Industry, Maejo University.

Prasert, W., and Suwannaporn, P. 2009. Optimization of instant jasmine rice process and its physicochemical properties. J. Food Eng. 95(5): 54–61.

Quartermaster Department. 2020. Field service manual on food logistic in the field. Quartermaster Department, Royal Thai Army, Thailand.

Suksomboon, A., and Limrungrueangrat K. 2019. Development of semi-instant rice products that reduce the glycemic index. Research report, Faculty of Science, Burapha University, Thailand.

Thailand Industrial Standards Institute. 2005. Thai Industrial Standards (TISI. 315/2005) Rice Porridge, Bangkok.

Vanavichit, A. 2020. Riceberry rice Thailand's antioxidant-packed nutraceutical and super food!. www.researchoutreach.org. (retrieved February 29, 2023).

Yamane, T. 1973. Statistics: An introductory analysis. 3rd ed. Harper and Row, New York.