Development of home-based ready-to-use supplementary food (RUSF-HB) to overcome nutrition-related problems among children under five during the covid-19 pandemic

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Abstract. The most direct causes of malnutrition are food consumption and infection. Yet the prolonged Covid-19 pandemic has limited low-income families’ ability to fulfil the need for nutrition consumption, particularly for children under five. Responding to this situation, we sought to develop home-based ready-to-use supplementary foods (RUSF-HB) from local ingredients that are energy-protein-dense, affordable, simple and easy to produce at home. We created three milk-free formulas (MFFs) and six standard formulas (STFs). Three cheap and abundant local foods: soybeans, cowpeas, and mung beans were combined with rice flour, refined sugar, and coconut oil. A cross-over study design was used to assess food organoleptic, which showed that the products were comparable in several sensory aspects except for the odour and the taste. Soybeans-based formulas contain slightly more energy and protein compared to mung beans or cowpeas-based ones. However, the mung beans-based formulas were more favourable to caregivers and children, particularly their taste and smell. The products contain slightly less energy than the recommended ones but high enough to supply macronutrient for those in need on a regular basis. The caregivers considered the total price for the products was affordable, and the formula was easy to follow.

1. Introduction
The Covid-19 pandemic has been affecting all aspects of life. Those of low socioeconomic classes have been reported to suffer the most from the global economic downturn following the pandemic [1]. With the prolonged pandemic, nutrition problems, particularly among children from such social classes, along with other vulnerable groups, are becoming more imminent [2]. As the risk of intra-hospital infection cannot be omitted [3], many families avoid seeking help from the public health centres, clinics or hospitals, due to the fear of the Covid-19 infection in those places. This implies that their access to health services has been limited, which possibly leave the malnourished children untreated.

Severe acute malnutrition children are treated using ready-to-use Therapeutic Foods (RUTFs) [4]. On the other hand, mild acute malnutrition children usually are given Ready-to-use Supplementary Foods (RUSF) [5]. Both RUSF and RUTF are very similar in their requirements, food characteristics and composition except that RUTF should be fed exclusively. Also, the dose of RUTF should be suited
to the children’s weight while the quantity of RUSF is normally fixed [5,6]. RUSF/RUTF is a mixture of highly nutritious foods intended for emergency and supplementary feeding for either malnourished children or individuals with special nutrition requirements.

Although The effectiveness of RUTF for improving individual nutrition status has been proved [7,8], many people cannot afford industry-grade RUTF. Commercial food supplements are considered costly, especially for those of lower-to-middle class families in developing countries [9] which limit their access to the food. Hence, to improve accessibility, some countries created their version of RUSF/RUTF from local ingredients to reduce the overall price [10]. In many places, RUTF is distributed to those in need free of charge. However, in some other locations, people do not have access to RUTF. With the spread of covid-19, the distribution of free RUSF/RUTF was almost interrupted entirely, leaving the vulnerable group in latent danger of malnutrition.

It is paramount to stay alert of potential malnourished issues among the vulnerable individuals during this economically challenging time [11]. It is necessary to find appropriate solutions to this issue amidst the pandemic and the economic downturn. The development of alternative RUSF/RUTF formulas from local foods potentially provides solutions for both health and economy issues during the pandemic Covid-19. Indeed, several crucial points should be taken into consideration when developing home-based RUSF/RUTF. These considerations include the principles of health, affordability, practicality, simplicity, and locality. The resulting foods should be able to reproduce at household without a sophisticate cooking utensil.

2. Objectives
To develop energy-dense home-based Ready-to-use Supplementary Food (RUSF-HB) from local produces that are easy to make at the household level to fight malnutrition issues among children under five during the Covid-19 Pandemic. Although we focused on developing supplementary foods, the finished products have the potential to use as therapeutic food in an emergency situation.

3. Methods
This research was done in two phases: Development phase and Evaluation phase

3.1. Development phase.
Development phase consisted of two steps: identifying typical local foods and creating formulas and recipes

3.1.1. Identifying typical foods. The first step was finding typical foods of the local community, which was done through observation in two local markets. To ensure the validity of the derived data, we also interviewed four locals.

3.1.2. Creating and analysing formulas. We created several combinations of ingredients. The formulas development was done based on the international practice of RUTF [6] with additional considerations such as affordability, practicality (easiness), simplicity, and locality of the process and the products.

We developed two groups of formulas: the first group was milk-free formulas (MFFs), which was created for mothers who have limited access to milk, either due to economic or geographic factors. For this target group, milk powder was dropped from the formulas. The other group was Standard Formulas (SFs) created by following standard practice of RUSF/RUTF development, which made use milk powder. The detailed combination of the formulas is presented in table 1.

To determine the macronutrient content of each combination, we referred to and consulted the latest Indonesian Food Composition database [12]. The primary method of processing involved steps: roasting, grinding, mixing serving/packaging.
1. Roast rice flour for approximately 30 minutes over low heat
2. Roast the beans over low heat for approximately 30 minutes. Ground the beans.
3. Mix all the ingredients according to the prescribed formula, stir evenly. Any available utensils (modern such as a food processor, or traditional/simple such as a spoon) can be used to mix all ingredients as long as they are evenly mixed.

4. The mothers are encouraged to use a beautiful and eye-catcher cake mould to attract children’s attention. However, when a cake mould is unavailable, the mother can use their creation using any available utensils.

3.2 Evaluation Phase

Evaluation phase consisted of two steps: a food test (organoleptic test) and real setting test.

3.2.1. Organoleptic test. The organoleptic/sensory test was performed to ensure the acceptability of the products among the target groups. We invited caregivers (mothers) as the proxy panellists for their children because using children panellists tends to be problematic. We asked the panellists to score each formula according to their best knowledge of their children’s preferences. It is understandable that mothers know best about their children’s characteristics; hence we assumed mothers’ response to the food test represents their children’s. Twelve semi-trained mother panellists participated in the test. They were given a brief training before the test commenced. The inclusion criteria for the panellist was that mothers should be a caregiver of an underweight or severe underweight child (a child who has Weight for Age Z Score of less than minus 2 (WAZ <= -2).

The panellists were randomly assigned into two groups: group A, who commenced the first organoleptic test with milk-free formulas, and group B, who started with the standard formulas. We used cross-over design, hence for the second test, the panellists were assigned to the other group (see figure 1).

3.2.2. Qualitative analysis of food acceptability. We chose the best formula (based on the organoleptic test result) from both groups. We provided raw materials based on the chosen formula and distributed it along with the recipe to 15 families with children under five who has nutrition problem or requiring special nutrition treatment. We asked the mother to reproduce the recipe and give the finished product to their children. After three days, we went on interviewing the caregivers to collect qualitative data to assess the acceptability and practicality of the products.
4. Statistical analysis
With regard to the organoleptic tests, both groups were analysed separately. Friedman’s two-way analysis of variance by rank was performed to determine differences among formulas in those two groups. As significant differences were observed, the test was continued using the Wilcoxon signed-rank test to identify differences between formulas. [13]

5. Ethics
The ethical clearance for this research was obtained from the Universitas Qamarul Huda Badaruddin (UNIQHBA) Ethics Committee, approval number: 0025.

6. Results and discussions
We created a total of nine formulas: three milk-free formulas (Group MFFs) and other six standard formulas (group SFs). Total weight for each formula was 100 grams.

6.1. The formula
The composition of each formula can be seen in the following tables. The food codes shown in the tables are used as a reference to the Indonesian Food Composition database [12].

| No | Food (Food Code)          | Formula 1 | Formula 2 | Formula 3 |
|----|---------------------------|-----------|-----------|-----------|
| 1  | Rice flour (AP004)        | 15 gr     | 15 gr     | 15 gr     |
| 2  | Soybeans (CR017)          | 40 gr     | -         | -         |
| 3  | Mung beans (CR014)        | -         | 40 gr     | -         |
| 4  | Cowpeas (CR033)           | -         | -         | 40 gr     |
| 5  | Refined sugar (MP007)     | 20 gr     | 20 gr     | 20 gr     |
| 6  | Coconut Oil (KR011)       | 25 gr     | 25 gr     | 25 gr     |

| No | Food (Food Code)          | Formula 4 | Formula 5 | Formula 6 | Formula 7 | Formula 8 | Formula 9 |
|----|---------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| 1  | Rice flour (AP004)        | 15 gr     | -         | 15 gr     | -         | 15 gr     | -         |
| 2  | Soybeans (CR017)          | 20 gr     | 40 gr     | -         | -         | -         | -         |
| 3  | Mung beans (CR014)        | -         | -         | 20 gr     | 40 gr     | -         | -         |
| 4  | Cowpeas (CR033)           | -         | -         | -         | -         | 20 gr     | 40 gr     |
| 5  | Skim milk (JP009)         | 20 gr     | 15 gr     | 20 gr     | 15 gr     | 20 gr     | 20 gr     |
| 6  | Refined sugar (MP007)     | 20 gr     | 20 gr     | 20 gr     | 20 gr     | 20 gr     | 20 gr     |
| 7  | Coconut oil (KR011)       | 25 gr     | 25 gr     | 25 gr     | 25 gr     | 25 gr     | 20 gr     |

The main ingredients of the product were rice flour, soy flour, mung beans, cowpeas, fine granulated sugar, and coconut oil. An optional ingredient: skim milk, may be added when possible. Each formula contains energy that varies from 457.00 kcal to 502.55 kcal, and protein ranges from 10.46 – 21.75 grams, which is a good amount of macronutrient for those requiring nutrition supplement. Details of the macronutrient content of the formula are illustrated in table 3.

Formula one and formula five scores the best for macronutrient contents as it has the densest energy-protein component in their group. Formula one and five contains 501.65 and 502.22 kcal of energy, 17.46 and 21.75 grams protein respectively which are needed to quickly restore body mass for those in
need of it. Formula five also has more fat than other formulas on the list and has the least amount of carbohydrate. Nonetheless, it has slightly lower kcal than international standard RUSF macronutrient content. The recommended energy value for RUSF is between 510 – 560 kcal, protein: 11 – 16 grams, fat 26 – 36 grams [5]. The recommended value for RUSF is almost identical to that of RUTF Energy: 520 – 550 kcal, Protein 10-12 % total energy, lipid 45-60% total energy [4].

Table 3. Macronutrient contents of each formula (100 grams).

|                | Energy (kcal) | Protein (grams) | Fat (grams) | Carbohydrate (grams) | Total cost/100 gr (US$) |
|----------------|---------------|-----------------|-------------|----------------------|------------------------|
| **Group 1 (MFFs)** |               |                 |             |                      |                        |
| Formula 1      | 501.65        | 17.46           | 31.26       | 40.76                | 0.09                   |
| Formula 2      | 478.45        | 10.46           | 25.18       | 53.52                | 0.10                   |
| Formula 3      | 481.65        | 11.06           | 25.34       | 53.44                | 0.11                   |
| **Group 2 (SFs)** |               |                 |             |                      |                        |
| Formula 4      | 497.25        | 16.50           | 28.12       | 46.18                | 0.20                   |
| Formula 5      | 502.55        | 21.75           | 31.33       | 36.56                | 0.17                   |
| Formula 6      | 485.65        | 13.00           | 25.08       | 52.56                | 0.21                   |
| Formula 7      | 479.35        | 14.75           | 25.25       | 49.32                | 0.19                   |
| Formula 8      | 487.25        | 13.30           | 25.16       | 52.52                | 0.22                   |
| Formula 9      | 457.00        | 17.08           | 20.56       | 51.84                | 0.23                   |
| Maximum        | 502.55        | 21.75           | 31.33       | 53.52                | 0.23                   |
| Average        | 485.64        | 15.04           | 26.36       | 48.52                | 0.17                   |
| Minimum        | 457.00        | 10.46           | 20.56       | 36.56                | 0.09                   |

With regard to affordability, we were able to minimise the total cost for each formula. The average price for the MFFs group was US$ 0.10/100 gram, halved the SFs group with the average cost of US$ 0.2/100 grams. This difference was affected by the addition of skim milk powder. We opted to use skim milk rather than full cream milk to minimise the product price. The price components in these products were only affected by the local market prices of the ingredients. The HB-RUSF price fluctuation was more predictable than commercial RUTF/RUSF in which price was affected by not only the core prices of the components but also the global competition of RUTF market [14].

Price analysis of the product shows that the cheapest formula was formula one, with only US$ 0.09 per 100 grams final product while the most expensive one was formula nine that cost US$ 0.23. From interviews with mothers who participated in the product testing, it emerged that even for the most expensive product on the list, the price was considered affordable. This signified that our price-wise principles were accomplished. Despite the lowest price, formula one contained total energy of 501.65, which was the most energy-dense formula in MFFs group. This was due to the use of soybean, which was the cheapest beans of the beans selected in this research. The price of soybeans in the local market was the cheapest among other beans. Yet soybeans contains the highest energy (381 kcal/100 gr) and protein (40.4 gr/100 gr) compared to mung beans and cowpeas [12].

Given the high price of milk, we provided the option milk-free formulas for mothers to allow them to choose the best formulas for their financial situation. In term of effectiveness as assessed through amino acid metabolism, however, a study showed that standard RUTF (with milk) and localised ones (milk-free with improved amino acid profile) had a comparable effect on amino acid metabolism to support nutritional recovery among severely malnutrition children under five [15].
6.2. Organoleptic analysis

Organoleptic analysis of group MFFs reveals that the formulas were similar in some sensory aspects including colour (p=0.971), texture (p=0.799), sweetness (p=0.273), saltiness (p=0.590), bitterness (p=0.125), rancid (p=0.572), and burnt (p=0.572). However, the difference was observed in the odour (p=0.000) and the taste (p=0.001). Further analysis showed that all three formulas in this group were all different in the odour. However, formula 2 appeared to be most favoured both in the odour and the taste among this group. The panellists were able to distinguish the odour and the taste of each formula. This was due to the distinct odour of each bean that can be perceived quite objectively by the panellists.

Among group SFs, we found differences in three aspects of sensory, including the odour (p=0.000), the sweetness (p=0.000), and the taste (p=0.000). All other sensory aspects were comparable statistically (p > 0.05), meaning that the panellists did not have any particular preferences in those aspects except for the odour, sweetness and taste. The more advanced statistical analysis showed that formula 7 was the most favourite formula both in the odour and the taste among other formulas in group SFs. Yet, formula 7 was not of the highest energy and protein contents. On the other hand, formula 5 that contains more energy was not as much acceptable as formula 2 or 7.

An interesting finding was that the products containing mung beans seemed to be superior with respect to the acceptability, odour, and taste. The panellist showed preferences toward formulas with mung beans both in group MFFs (formula 2) and SFs (formula 7). The taste and the odour of both formulas statistically more acceptable to the panellists. The interviews following the organoleptic test revealed that caregivers were confident that their children would prefer the product with mung bean better than the ones with cowpeas or soybeans. This was because generally their children had been introduced to mung bean flavoured as weaning commenced, that was about six months old. Furthermore, children often are given mung bean porridge in Posyandu (integrated health post) as part of the Posyandu program, which helped to develop their preference and familiarity toward mung beans.

Another issue that worth considering is the colour of the formulas. As described by the caregivers, the colour of the products might be unattractive for children. The colour indeed is one of the crucial factors to consider when preparing food for children as research has found that food colour influences children choice of food [16]. However, as we focused on practicality, simplicity, and affordability, we dropped the option for colour enhancement from our RUSF-HB as we tried to create the most economical composition of ingredients, although we were aware that children generally prefer coloured food [17, 18]. Besides, we did not prescribe colour agent in our formula for the fear that the less educated mothers might mistakenly use inappropriate colouring agents such as textile dyes rather than food colouring, which was quite common mistakes in villages. On top of all, the new RUSF/RUTF standards that endorsed by the UNICEF prefer cream to light colour or orange-brown colour [6], which exactly was the colour of this finished products (see figure 2 and 3).

The original texture of the product was generally a relatively smooth sticky flour. However, the final texture that served to children is dependent upon the process of grinding, printing / pressing into a cake mould. This means that the texture of the finished product can be adjusted to mothers’ wishes. During the printing, we also found that adding a little fresh water to the mixture helps to improve the final texture. However, adding water to the product that was intended to store for days is not recommended as it increases the chances of bacterial multiplication in the product [5, 19]. The texture of this RUSF was a little differ from the common texture of the standard RUSF such as thick paste that easy to squeeze out of a sachet [6]. The prescribed texture of therapeutic food was regarded as less important because the product was not intended to be mass-produced, nor to be stored for a long time.

With regard to odour, fresh odour of the beans used in this formula, particularly mung beans, was not pleasing for the panellists. Yet, we found that the addition of skim milk to the formula helps to neutralise the discernible odour of the beans. This explains why the odour score of the formulas from group SFs scored better than those in group MFFs. The odour of the finished product appears to comply with the UNICEF new standard such as free from foreign odours and flavours [6].
6.3. Food acceptability: qualitative analysis

After the organoleptic test was done, we distributed samples of formula two and formula seven to fifteen families with underweight children in order to access the children acceptability of the formulas in their natural setting. We perform interviews with the families three days after formulas distribution. We found that participating children and family enjoy the products as expressed by the mothers “my kid like it so much that she asked for it multiple time in the first day” and “he likes playing with it, smell and then eating it”. Also, some mothers claimed to have tasted the food themselves and found it “familiar in the tongue”. All respondents have agreed that the food was easy to make. Yet few mothers do not like the idea of using skim milk as it was thought to be costly. When the option for non-milk was given, however, participants split with more than half preferred to use skim milk while others dropped it for economic reason.

We also asked the mothers to explain their opinion regarding these formulas and how they view the formulas in regard to the family’s need for food and nutrition, particularly during the pandemic Covid-19. As they had been informed that the formulas were of high energy food, the majority of the mothers saw these formulas as a doable alternative that can help them to fulfil their children’s need for extra nutrition. With ‘doable’ we mean that the formulas were easy and affordable enough for mothers to make, even during this tough situation of the pandemic. Mothers also viewed these nutritious supplementary foods as simply a ‘snack’ that can be given to not only underweight children but also to normal children. Many of them served the formulas to normal adults as alternative foods to be consumed in the afternoon tea. Hence, as part of ethics consideration, we gave education for these families that the use of the formulas as a regular snack without proper control possibly create other problems such as the overweight due to the density of energy and protein of the food [20]. More importantly, the formulas were designed as supplementary foods for mildly malnourished children. But in case of emergency, the products can also be used as a treatment for severely malnourished children. However, the exclusive and prolonged usage of the formulas to treat severely malnourished children is not recommended as the products contain slightly less energy than the recommended ones, and the texture is not in the form of a paste which is a requirement for standard therapeutic food.

The strength of these formulas lies in the use of local materials that are affordable and can be obtained around the community, which allow home-based care for those with nutrition problems. Home-based care of malnourished children allows saving financial resources [21] from the reduced cost of the overall treatment. Moreover, the selection of local ingredients has an impact on the acceptance of many sensory aspects that effortlessly suit the locals’ taste. Yet, the selection of local foods as the main component of RUSF/RUTF should proceed carefully as not all local food be equally accepted as demonstrated in a Cambodian study of Fish-based RUTF [22].
7. Limitations
There was no laboratory test performed to determine nutrient loss during the processing. However, as all ingredients used were of standard and typical food with no sophisticated processing, we were confident to assume that there would be insignificant loss of nutritional content. There was no product storage stability test performed because the initial intention of developing HB-RUTF was to be produced at the household level and be consumed immediately or within a short time. This means that we could not determine how long the product can be safely stored before expired although we were also aware that bean-based RUSF/RUTF commonly regarded safe to store the product for twelve months and some products were proved to be stable over 18 months [23]. For a scale-up development, however, thorough laboratory test, including nutrient content after processing, metal contamination, and food storage stability, would be a necessity.

8. Conclusions
We were able to create simple RUSF-HB formulas using common local foods that needed only simple processing with available cooking utensils. The RUSF-HB is a viable, doable and affordable alternative to the more expensive industrial-grade mass-produced supplementary foods as it uses only locally-produced ingredients. The formulas were easy enough to reproduce, and the caregivers (mothers) were provided with a flexible option: to use or drop milk powder from the formula dependent upon their circumstances. Except for the odour and taste, all developed formulas were comparable in most sensory aspects. Soybeans-based formulas tended to be less expensive and contain more macronutrients but were poorly rated for their organoleptic test. On the other hand, mung-beans formulas scored better in their organoleptic test, although containing slightly less energy and protein compared to soybeans-based formulas. Formula 2 and formula 7, both were mung beans-based formulas, emerged as the most acceptable formulas for children and their caregivers. These formulas can supply extra nutrient to mild acute malnutrition children or used as treatment foods in the event of an emergency for severely malnourished children, particularly during the Covid-19 pandemic.

9. Recommendations
The further clinical test is warranted to access the real contribution of the developed RUSF-HB formulas to the improvement of general nutrition status of malnourished children. In addition, as we notice soybean-based formula have more energy and protein content but were scored down from its odour, further research might need to find ways to eliminate the strong odour of soybeans while improving colour and texture of the final products. This helps to provide a wider range of RUSF-HB for mothers and children to choose from.

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