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Safety and Quality of Complementary Food (MPASI) as Disaster Emergency Rations Using Retort Pouch Packaging Technology

Keamanan dan Kualitas Makanan Pendamping ASI (MPASI) Ransum Bencana dengan Teknologi Pengemasan Retort Pouch

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ABSTRACT

Background: Natural disaster is frequently causing disruptions to food availability, including complementary food (MPASI) for toddlers. Therefore, innovation in MPASI as disaster emergency rations with long shelf life and safe for consumption is required through retort pouch packaging technology.
Objectives: This research aimed to evaluate safety and quality of MPASI using retort pouch technology during different storage periods.
Methods: The experiment was carried out using a single-factor Completely Randomized Design (CRD) method. The treatment factor used was storage periods of 7, 14, and 21 days with 2 repetitions. Analysis of nutritional content including moisture, carbohydrate, protein, fat, and ash as well as safety aspects was carried out through total bacteria count test using the pour plate method. The preparation of MPASI included formulating ingredients such as rice, egg, carrot, green onion, and butter, followed by packaging in retort pouches, sealing, and sterilizing at 121.5°C for 15 minutes. The data analysis used was Analysis of Variance (ANOVA) to determine significance among treatments.
Results: The results showed that there was no significant effect of the storage periods on the nutritional content of carbohydrates (p-value = 0.272), protein (p-value = 0.730), fat (p-value = 0.748), ash (p-value = 0.848), and moisture (p-value = 0.806). Similarly, there was no significant effect of storage periods on total bacteria count where the value was still in safe limits (<10 colonies/g).
Conclusions: Retort pouch packaging showed the potential to increase the shelf life of MPASI as well as maintain safety and quality.

INTRODUCTION

In the last decade, the frequency of disaster is continuously increasing annually reaching approximately 3,000–3,500 events over the last 5 years. This is because Indonesia is located in the Ring of Fire, serving as an earthquake-prone area, with a significant increase in the number and intensity of earthquakes since 2013[1]. Natural disaster often has a significant impact on the availability and access to food, particularly for vulnerable groups such as toddlers during the exclusive breastfeeding period given for 2 years or 24 months. In emergency conditions, nutritional needs become essential due to the direct influence on the health of breastfed toddlers. Imbalanced nutritional intake can increase the risk of malnutrition, growth disorders, and development[2]. Malnutrition during the critical period of toddler growth in emergency situations has serious impacts that are immediate and long-term. Therefore, the high frequency of disaster in Indonesia shows the need to provide safe and nutritious food solutions for toddlers in disaster emergency conditions.

Providing complementary food (MPASI) in the form of disaster emergency rations is one solution that can be implemented to maintain nutritional adequacy. MPASI rations are designed to provide complete nutrition, easy consumption, and are long-lasting, showing the potential to be administered in conditions of limited access to food. Moreover, retort pouch packaging technology can support the development of emergency MPASI rations[3]. This technology is a type of flexible packaging with high resistance to heat, allowing food products to be processed with high-temperature sterilization and remain durable for a long time without the need for additional preservatives[4]. With packaging technology, there is a great opportunity to develop safe and nutritious emergency MPASI products with a long

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shelf life, serving as an ideal solution to support food security in disaster-prone areas.

The use of retort pouch in emergency MPASI rations for toddlers offers several advantages, including the ability to maintain nutritional quality, practicality in storage[5] and distribution, as well as food safety for a long time[6]. This is essential considering that emergency situations often hamper the distribution of fresh food and the availability of adequate storage facilities. Therefore, this research aimed to examine the potential and benefits of retort pouch in developing MPASI as emergency rations in disaster situations using retort pouch packaging technology. Evaluation of safety and quality of MPASI packaged using retort pouch is an important aspect of developing this food.

METHODS

This research used an experimental design with a single-factor Completely Randomized Design (CRD). The factor tested was the storage periods of MPASI for emergency rations with retort pouch packaging technology. The storage periods consisted of 3 treatment levels, namely 7, 14, and 21 days, with 2 repetitions. This method aimed to evaluate safety and quality of MPASI during different storage periods.

The materials used were MPASI formulated to fulfill the standard nutritional needs of toddlers during the exclusive breastfeeding period for 24 months. MPASI menu designed had a texture close to ordinary food for ages 12-23 months, with the main ingredients being rice (Oryza sative), eggs, carrots (Daucus carota L.), spring onions (Allium fistulosum L.), and butter. Rice served as the main source of carbohydrates, eggs produced protein, while carrots and spring onions provided essential vitamins and minerals, with butter functioning as a source of fat and adding calories.

The formulation of MPASI menu designed for toddlers aged 12-24 months is as follows, daily macronutrient requirements according to AKG are 1350 kcal of energy, 20 grams of protein, 45 grams of fat, and 215 grams of carbohydrates. Assuming that the acquisition of nutrients from breast milk is 70% and MPASI is 30%, the composition of nutrients in the MPASI menu is 945 kcal, 14 grams, 31 grams, 150.5 grams of energy, protein, fat, and carbohydrates, respectively. At a daily meal frequency of 2-3 main with a single portion of 125-250 ml, MPASI formulation in the main menu of fried rice with butter has the various ingredients composition as shown in Table 1.

Table 1. Composition of MPASI menu for infants aged 12-24 months

Ingredients	Weight (gr)	Requirements per 100 gr				Nutritional content (gr)			
		E (kcal)	P (gr)	L (gr)	KH (gr)	E (kkal)	P (gr)	L (gr)	KH (gr)
Rice	40	357.0	8.4	1.7	77.1	142.8	3.4	0.7	31
Egg	45	147.0	12.6	9.9	0.7	66.1	5.7	4.5	0
Carrot	30	36.0	1.0	0.6	7.9	10.8	0.3	0.2	2
Spring onion	10	61.0	1.5	0.3	14.1	6.1	0.2	0.0	1
Butter	5	742.0	0.5	81.6	1	37.1	0.0	4.1	0
Total Nutritional Content						262.9	9.5	9.4	35

Description: P (Protein), L (Fat), KH (Carbohydrate)

The ingredients for MPASI menu were obtained from the traditional market of Rungkut Mejoyo, Surabaya, East Java. Packaging was retort pouch designed to maintain product quality during storage. The process of making MPASI included preparing the ingredients according to the formulation specified in Table 1, followed by packaging into retort pouch and sealing. After packaging, the sterilization process was carried out using retort at a temperature of 121.5°C and for 15 minutes to ensure the microbiological safety of the product. MPASI sample was stored at room temperature for 7, 14, and 21 days. Tests were carried out on days 0, 7, 14, and 21 to evaluate changes in quality. The tested parameters included proximate analysis such as moisture, ash, protein, fat, and carbohydrate content, as well as microbiological analysis (Total Plate Count).

Proximate Analysis: Moisture Content

Moisture content analysis was conducted using the gravimetric method according to the AOAC procedure[7]. Initially, the porcelain dish was dried in an oven for 30 minutes (T 105°C) and in a desiccator for 30 minutes. The sample of ±5 grams was weighed and crushed, put into a dish, and weighed. Furthermore, the dish containing the sample was dried in an oven for 6 hours, and cooled in a desiccator for 30 minutes. The calculation of moisture content was carried out using the following formula.

%moisture=$A-BC$x100%%moisture=A−BCx100%

Description:
A = weight of dish and sample before drying
B = weight of dish and sample after drying
C = initial weight of sample

Proximate Analysis: Ash Content

Ash content analysis was carried out using the gravimetric method referring to AOAC[7]. The initial stage was preparation by drying the porcelain dish using a furnace for 30 minutes (T 600°C), followed by cooling in a desiccator for 30 minutes. The sample was crushed and weighed to obtain ±5 grams, which was put into a dish and dried in a furnace for 6 hours (T 400-600°C). The dish containing the sample was cooled in a desiccator and weighed. The calculation of ash content was carried out using the following formula.

%ash=$A-BC$x100%%ash=A−BCx100%

Description:
A = weight of dish and sample after ashing

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B = weight of dish
C = initial weight of sample

Proximate Analysis: Protein Content

Protein content analysis was carried out using Kjeldahl method through 3 stages, namely destruction, distillation, and titration according to AOAC procedure[7]. In the destruction stage, the sample was crushed and weighed at ±1 gram. The sample was put into Kjeldahl flask with 3 grams of $CuSO_4$, 7 grams K_2SO_4, and 15-25 ml H_2SO_4, followed by homogenization. Kjeldahl flask was heated on a destruction stove until the mixture became clear and did not smoke. Subsequently, distillation was carried out by putting the destruction results into the distillation flask. Approximately 25 ml of 50% NaOH, Zn powder, and distilled water were added to half of the distillation flask. In the distillate container, 25 ml of 0m1 N HCl and 5 drops of methyl red indicator were added and the distillation process was carried out until the results reached ±100 ml. The titration stage was performed on the distillation results using 0.1 N NaOH until the solution turned orange. Protein content was calculated using the following formula:

$\%protein=(V2-V1)NaOH\ x\ N\ NaoHx14{,}008xfksampl$
e
weight $(mg)x$ 10x100%%protein=V2−V1NaOH x N NaoH x14,008xfksample weight mgx 10x100%

Description:
V_1 = volume of NaOH for blank titration
V_2 = volume of NaOH for sample titration
Fk = protein conversion factor (6.25)

Proximate Analysis: Fat Content

Fat content analysis was carried out using the Soxhlet method[7], where the flask containing the sample was dried in an oven and cooled in a desiccator. The flask was weighed, fitted with a soxhlet, and the sample was prepared by grinding ±2 grams and wrapping in filter paper to form a sleeve. The filter paper was inserted into the soxhlet and hexane solvent was added until the sample was submerged. The soxhlet was fitted with a condenser and extraction was carried out for 6-8 hours. Furthermore, the flask containing fat was oven-dried for 1 hour to evaporate the remaining solvent, cooled, and weighed to obtain fat content, which was calculated using the following formula:

%fat=$W2-W1sample$
weight$x$100%%fat=W2−W1sample weightx100%

Description:
W_1 = weight of empty fat flask
W_2 = weight of fat flask with extraction results

Proximate Analysis: Carbohydrate Content

Carbohydrate content analysis was performed using the by-difference method with the following equation.

%carbohydrate = 100% - content (moisture+ash+protein+fat)

Total Bacteria

The pour plate method was applied to calculate total bacteria in food samples, including MPASI. In this method, the sample dilution was mixed with melted agar media, cooled to approximately 45°C, poured into a sterile petri dish, and allowed to solidify. The media commonly used was plate count agar (PCA) consisting of nutritional components such as peptone, yeast extract, glucose, and agar as a solidifier. After the media solidified, the dish was incubated at the optimal temperature for bacterial growth, generally 30-37°C, for 24-48 hours. During incubation, the bacteria in the sample grew to form separate colonies that could be counted. After the incubation period, the number of growing colonies was counted using a colony counter or manually. The calculation results were multiplied by the dilution factor to obtain total bacteria count in the original sample, often expressed in colony-forming units (CFU) per gram or milliliter of sample. This pour plate method allowed for an even distribution of bacterial cells in the media, thereby providing fairly accurate results for total bacteria count. Proximate analysis of moisture, ash, protein, fat, and carbohydrate content as well as total bacteria was carried out at PT Sarawanti Indogenetech (SIG) Analysis Testing Laboratory, Bogor.

Data Analysis

The data obtained from the test were analyzed using Analysis of Variance (ANOVA) to determine whether there were significant differences between the treatments tested. When a significant difference was found, the analysis was continued with Duncan's Multiple Range Test (DMRT), with the level criterion set at 5% ($\alpha = 0.05$). Before ANOVA test was carried out, the normality of the data was tested using the Shapiro-Wilk method. When the p-value from the normality test was greater than 0.05, the data was considered normally distributed.

Research Ethics

This research is still an initial investigation that identifies chemical and microbiological characteristics, without interventions in either animal or human trials to ensure safety. The next follow-up research is to identify the shelf life with the accelerated method (Accelerated Shelf Life Test (ASLT)) and interventions in identifying organoleptic characteristics as well as the effectiveness and variety of MPASI forms.

RESULTS AND DISCUSSIONS

Data on the nutritional content and total bacteria of MPASI as disaster emergency rations are shown in Table 2., with treatments as storage periods of 7, 14, and 21 days. Meanwhile, the normality test (Shapiro-Wilk) on each variable showed that both moisture, ash, protein, fat, and carbohydrate content had normally distributed data (p-value> 0.05).

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Table 2. Nutritional content and total bacteria of MPASI* as disaster emergency rations

Factor	*Moisture Content*	*Ash Content*	*Protein Content*	*Fat Content*	*Carbohydrate Content*	*Total Bacteria*
MPASI 7 days	68.27 ± 1.48	0.66 ± 0.191	5.40 ± 0.44	5.62 ± 1.26	20.07 ± 0.03	<10
MPASI 14 days	67.62 ± 1.2	1.91 ± 0.13	5.87 ± 0.99	6.13 ± 0.17	18.48 ± 0.51	<10
MPASI 21 days	66.96 ± 2.72	0.66 ± 0.04	5.28 ± 0.69	6.13 ± 0.10	20.97 ± 2.09	<10

*Complementary Food

Moisture Content

ANOVA results showed no significant difference in moisture content between the 3 storage groups. The resulting F-value was 0.233 with a p-value of 0.806, which was greater than the significance threshold of 0.05. This suggested that moisture content of MPASI remained stable during storage. The stability of moisture content was an important indicator in determining food safety and quality, particularly for products stored for long periods. In this context, moisture content did not change significantly, indicating that retort pouch packaging technology could protect MPASI from humidity fluctuations and influence the texture, taste, and nutrition of the product[8]. Generally, retort pouch technology shows advantages in maintaining food stability, including humidity and protection against microorganisms[4]. This packaging uses a high-temperature sterilization process that kills microbes as well as materials capable of blocking air and moisture exchange. Therefore, MPASI stored in retort pouch remains safe to consume after 21 days of storage, serving as an ideal solution for distribution in disaster areas or other emergency situations. Regarding food distribution, retort pouch packaging is ideal due to the ability to maintain food quality during medium-term storage. This product maintains good quality in terms of moisture content for at least 21 days of storage, showing potential as an essential method for food distribution in disaster areas.

Ash Content

Based on ANOVA results on ash content data of MPASI as emergency rations with retort pouch packaging technology, an F-value of 2.233 was obtained with a p-value of 0.255. A p-value greater than the significance level of 0.05 showed no significant difference in ash content between the 3 storage groups (7, 14, and 21 days). This suggested that retort pouch packaging technology could maintain the stability of ash content in MPASI during the storage period.

The stability of ash content during storage is an important indicator of food safety and quality, particularly products stored for long periods such as emergency rations. These results were in line with previous research[9] where the use of retort pouch maintained the physical and chemical characteristics of food products during storage. The ability of retort pouch to maintain ash content stability was due to the nature of the material which was resistant to high temperatures, thereby preventing air and moisture exchange with the outside environment[6].

Retort pouch packaging technology has been proven effective in maintaining quality of MPASI as disaster emergency rations. The high-temperature sterilization process applied in this technology could kill microbes and prevent contamination[10], thereby the product remained safe to consume even after 21 days of storage. This is essential in food distribution in disaster areas or emergency situations due to limited access to food sources and safe storage. The stability of ash content during storage also showed that the mineral content in MPASI was maintained. This is an essential aspect considering the importance of mineral intake for the growth and development of toddlers, particularly in emergency situations. Adequate nutrition is also important through MPASI to prevent nutritional problems in disaster-prone areas[11].

Protein Content

Based on ANOVA results on protein content data of MPASI as disaster emergency rations with retort pouch packaging technology, F-value of 0.7076 was obtained with a p-value of 0.5566. The p-value greater than the significance level of 0.05 showed no significant difference in protein content between the 3 storage groups (7, 14, and 21 days). This suggested that retort pouch packaging technology could maintain the stability of protein content in MPASI during the storage period.

The stability of protein content during storage is an important indicator of food safety and quality, particularly products stored for long periods such as disaster emergency rations. The use of retort pouch can maintain the physical and chemical characteristics of food products during storage[12]. The ability of retort pouch to maintain the stability of protein content is due to the nature of the material which is resistant to high temperatures, preventing air and moisture exchange with the outside environment[13].

Retort pouch packaging technology has proven effective in maintaining protein quality of MPASI as disaster emergency rations. The high-temperature sterilization process applied in this technology can kill microbes and prevent contamination, thereby the product remains safe to consume even after 21 days of storage[14]. This is crucial in the context of food distribution in disaster areas or emergency situations, where there is limited access to food sources and safe storage.

The stability of protein content during storage shows that the nutritional value of MPASI is maintained. This is a crucial aspect considering the importance of protein intake for the growth and development of toddlers, particularly in emergency situations. Furthermore, there is a need to ensure adequate nutrition in MPASI to prevent nutritional problems among toddlers in disaster-prone areas. Protein is a macronutrient functioning as a building block, serving as a maintainer of body cells and tissues, which helps in metabolism of the immune system[15]. The stability of protein content in MPASI as disaster emergency rations during storage for 7, 14, and 21 days shows the

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effectiveness of retort pouch packaging technology in maintaining product quality. This makes MPASI a reliable solution for providing nutritious food in emergency or disaster situations.

Fat Content

Based on ANOVA results on fat content data of MPASI as disaster emergency rations with retort pouch packaging technology, an F-value of 0.2729 was obtained with a p-value of 0.7752. A p-value greater than the significance level of 0.05 showed no significant difference in fat content between the 3 storage groups (7, 14, and 21 days). This suggested that retort pouch packaging technology could maintain the stability of fat content in MPASI during the storage period.

The stability of fat content during storage is an important indicator of food safety and quality, particularly for products stored for long periods such as disaster emergency rations. The ability of retort pouch to maintain stable fat content is due to the nature of the material which is resistant to high temperatures, preventing air and moisture exchange with the outside environment. Fat degradation caused by oxidation can reduce product quality and calorie content, which is important in emergency situations. However, this research found no significant decrease in fat content, showing that the rations still fulfilled energy and nutritional needs during the storage period[5].

Retort pouch packaging technology was proven effective in maintaining fat quality of MPASI as disaster emergency rations. The high-temperature sterilization process applied in this technology could kill microbes and prevent contamination, thereby the product remained safe to consume after 21 days of storage. This is essential in the context of food distribution in disaster areas or emergency situations, where there is limited access to food sources and safe storage.

The stability of fat content during storage shows that the nutritional value of MPASI is maintained. This is an essential aspect considering the importance of fat intake for the growth and development of toddlers, specifically in emergency situations. Furthermore, efforts to ensure adequate nutrition through MPASI are important to prevent nutritional problems among toddlers in disaster-prone areas[16]. Fat is a macronutrient that functions as a source of energy and helps the absorption of fat-soluble vitamins essential for toddlers' growth and development.

The use of retort pouch technology in packaging of MPASI as disaster emergency rations provides a practical solution to ensure the availability of nutritious food in disaster-affected areas. Retort pouch packaging allows food to be easily distributed to disaster-affected areas and is strong enough to be dropped from a height, serving as an ideal for emergency situations[17]. The stability of fat content in MPASI during storage for 7, 14, and 21 days shows the effectiveness of retort pouch packaging technology in maintaining product quality.

Carbohydrate Content

Based on the ANOVA results on carbohydrate content data of MPASI as disaster emergency rations with retort pouch packaging technology, an F-value of 1.078 was obtained with a p-value of 0.4787. A p-value greater than the significance level of 0.05 showed no significant difference in carbohydrate content between the 3 storage groups (7, 14, and 21 days). This suggested that retort pouch packaging technology could maintain the stability of carbohydrate content in MPASI during the storage period.

The stability of carbohydrate content during storage is an important indicator of food safety and quality, particularly for products stored for long periods such as disaster emergency rations. Similarly, previous research stated that the use of retort pouch maintained the physical and chemical characteristics of food products during storage[18]. The ability of retort pouch to maintain the stability of carbohydrate content was due to the nature of the material resistant to high temperature, preventing air and moisture exchange with the outside environment[19].

Retort pouch packaging technology has proven effective in maintaining quality of carbohydrate content in MPASI as disaster emergency rations. The high-temperature sterilization process applied in this technology can kill microbes and prevent contamination, hence, the product remains safe to consume even after 21 days of storage. This is important in the context of food distribution in disaster areas when there is limited access to food sources and safe storage.

The stability of carbohydrate content during storage shows that the nutritional value of MPASI is maintained. This is an important aspect considering the benefits of carbohydrate intake for the growth and development of toddlers, particularly in emergency situations. This can be attributed to the better stability of carbohydrates than other nutritional components, such as fat, which are more susceptible to oxidation. In the context of short to medium-term storage (21 days), carbohydrate content in MPASI remains stable, fulfilling the energy needs of individuals in emergency situations. Therefore, there is a need to ensure adequate nutrition in MPASI to prevent nutritional problems among toddlers in disaster-prone areas[20]. Carbohydrates are the main energy source needed for optimal growth and development of toddlers.

The use of retort pouch technology in packaging of MPASI as disaster emergency rations provides a practical solution to ensure the availability of nutritious food in disaster-affected areas. This packaging allows food to be easily distributed to disaster-affected areas and is strong enough to be dropped from a height, serving as an ideal solution for emergency situations[18]. The stability of carbohydrate content in MPASI as disaster emergency rations during storage for 7, 14, and 21 days shows the effectiveness of retort pouch packaging technology in maintaining product quality. This makes MPASI packaged a reliable solution for providing nutritious food in emergency or disaster situations.

Total Bacteria

Based on the analysis results on total bacteria of MPASI as disaster emergency rations packaged with retort pouch technology, total bacteria count in all samples with storage periods of 7, 14, and 21 days showed a value of <10 CFU/g. These showed that retort

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pouch packaging technology was effective in maintaining the microbiological quality of MPASI during the storage period.

Microbiological stability indicated by low total bacteria (<10 CFU/g) in all samples during 21 days of storage showed the effectiveness of the sterilization process and the ability to retort pouch packaging to prevent microbial contamination. Food products packaged with retort pouch are able to maintain their microbiological quality during storage[21]. The high-temperature sterilization process applied in retort pouch technology effectively kills microbes and prevents bacterial growth during storage.

The ability of retort pouch to maintain the microbiological quality of MPASI during 21 days of storage is essential in the context of disaster emergency rations. Retort pouch packaging has good barrier properties against oxygen, moisture, and microorganisms[15], showing potential to extend the shelf life of food products. This makes retort pouch technology an ideal solution for packaging of MPASI as emergency rations require a relatively long shelf life and maintained microbiological stability. Furthermore, the use of retort pouch packaging can suppress microbial growth in food products during storage, as shown by the significantly lower total bacteria compared to conventional.

Microbiological stability of MPASI packaged with retort pouch for 21 days of storage has important implications for food safety, particularly for toddlers as vulnerable groups. Controlling microbial growth is a key factor in maintaining safety and quality of MPASI. With a consistent total bacteria of <10 CFU/g for 21 days of storage, MPASI as disaster emergency rations packaged with retort pouch can be considered safe for consumption from a microbiological perspective[12].

This research showed that retort pouch was effective in maintaining nutritional stability (carbohydrates, protein, fat, and moisture) and microbiological safety of the product for approximately 21 days of storage, which was suitable for emergency conditions. The results presented an innovative solution for toddlers food needs in disaster areas, using packaging technology that allowed for a longer shelf life without preservatives. Meanwhile, the disadvantage was that the stability test showed product safety was only for 21 days, limiting information about the potential for a longer shelf life.

CONCLUSIONS

In conclusion, this research showed that the application of retort pouch to MPASI in the form of emergency rations was effective in maintaining product safety and quality during storage. Product quality indicated by proximate analysis including moisture, ash, protein, fat, and carbohydrate content showed no significant difference between the 3 storage groups (7, 14, and 21 days). Regarding microbiological safety, total bacteria analysis results showed good consistency with a value of <10 CFU/g in all samples during 21 days of storage. These results proved that retort pouch technology was effective in preventing bacterial growth and maintaining product sterility, which was essential for safety of MPASI consumption, particularly in emergency or disaster situations.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

NN: conceptualization, methodology, project administration, supervision, funding acquisition, writing – original draft and editing; IF: conceptualization, methodology, supervision, formal analysis, data curation, writing-review, and editing; ESM: resources, software, visualization, and writing – editing.

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