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Development of pilot plant scale instant porridge production line for contribution to stunting prevention

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Abstract

This study aims to develop an efficient and hygienic pilot plant–scale production line for instant porridge as complementary food to support stunting prevention efforts in Indonesia. A descriptive engineering approach was applied, utilizing Operation Process Charts (OPC), Multi-Product Process Charts (MPPC), and routing sheets to model production flows, determine machinery requirements, and evaluate layout alternatives. Pilot-scale trials were conducted using a steam jacket kettle, drum dryer, disc mill, and vibrator screen to assess process capacities and product quality. The findings show that a three-batch cooking system provides the highest operational efficiency, allowing continuous drying at a rate of 5 kg of paste per hour and yielding 7.5 kg of instant porridge flakes per day. Three facility layout configurations—straight-line, zig-zag, and U-shaped—were identified as feasible design options, with the straight-line layout offering the shortest material movement and lowest contamination risk. Chemical, physical, microbiological, and sensory analyses confirmed that the product meets national standards for instant complementary foods. The study concludes that the proposed production line is technically feasible, scalable, and suitable for adoption by Micro, Small, and Medium Enterprises (MSMEs). Its implementation may enhance production efficiency, ensure food safety, and expand access to nutritious complementary foods, thereby contributing to national stunting reduction initiatives.

Keywords: Drying, Instant porridge, Production line, Stunting.

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1. Introduction

Based on the results of Basic Health Research in 2013 and 2018, the prevalence of stunting in Indonesia reached 37.2% and 30.8% [1]. Accelerating the reduction of stunting prevalence has become the focus of the Indonesia government in 2020-2024. Indonesian Ministry of National Development Planning targets that by 2024 the prevalence of stunting among children under five in Indonesia will decrease to 14.0%. Accelerating stunting reduction by carrying out specific nutritional interventions and sensitive nutrition interventions for the target group of the First 8000 days of life, starting from adolescents, brides-to-be, pregnant women, breast feeding mothers, and children aged 0-59 months [2].

AZ-score indicator is height of body to age less than -2 SD indicates stunting, a failure to grow in children under five due to chronic malnutrition, especially in 1000 days of life [3]. According to World Health Organization (WHO) [4] the leading causes of stunting are (1) nutritional intake, (2) parenting, and (3) clean water and sanitation. Increasing nutritious food intake is one of the programs of specific nutrition interventions. The development of instant porridge as a complementary food for breast milk is a local food innovation contributing to stunting prevention. It can be given to babies aged 6–23 months. The complementary food of instant porridge recipe uses mocaf flour for carbohydrates source, skimmed milk and tempeh flour for protein source, it is better with fortification of micronutrient premix and enrichment of inulin [5].

A cylinder dryer is the leading equipment to support the complementary food of instant slurry production process. A double-cylinder dryer prototype was produced and tested in 2020-2021 [6]. The double-cylinder dryer products produced have a 10 kg/batch capacity with Nip system feeding. The tool is 1600 mm long, 1150 mm wide, and 2050 mm high. The dryer cylinder is made of ferro cast ductile (FCD) 450 cast iron coated with hard chrome with dimensions of 500 mm in diameter, 400 mm in length, and 20 mm thick. The motor power of the drive of the double-cylinder dryer designed to be built is 3 phase. The movement of the dryer cylinder can be adjusted by using an inverter with a rotation ranging from 0.5 rpm-rpm to rpm.

Increasing the production scale from the laboratory scale to the pilot plant scale is necessary because it is feared that product quality will change. Scott, et al. [7] stated that increasing the laboratory scale to the pilot plant scale requires adjusting the formula. Considerations for the gradual increase in production scale include technical factors, machine/equipment capacity, material requirements, process time, number of working hours, human resources, availability of production space buildings, and others.

The process of optimizing the formula on the laboratory scale and the pilot scale has been carried out. Concerning transferring technology to Micro, Small, and Medium Enterprises (MSMEs), it is necessary to develop the production line; this aims to design production spaces in MSMEs with other supporting facilities that are the most effective, efficient and economical, so that they can improve work performance and productivity and minimize the occurrence of physical, chemical and microbiological contamination from one process to the next. MSMEs can build production lines for instant porridge by utilizing flexibility, adaptability, and proximity to the community to produce and distribute nutritious porridge at affordable prices so that they can contribute to reducing stunting of toddlers as targets for specific interventions [8]. This research aims to develop a pilot plant-scale instant porridge production line that can be transferred to MSMEs to accelerate toddler stunting.

2. Methods

This study used a descriptive research method that includes both qualitative and quantitative methods. The goal was to describe the process of developing a production line by looking at available criteria, needs, and resources. This way, a production line could make instant porridge on a pilot plant scale. The technology could then be transferred and fully tested in MSMEs.

2.1. Pilot Plant Scale Instant Porridge Production Process

Herminiati, et al. [5] state that laboratory-scale research outcomes are what the term "instant porridge production process" refers to. The capacity of 10 kg/batch is carried out as a database for the scale of the pilot plant, with the following production stages: (1) Mixing raw materials and supporting materials from modified cassava flour (mocaf), tempeh flour, skimmed milk, inulin, powdered sugar, palm oil, micronutrient premix (a mixture of Fe, Zn, vitamin B1, vitamin B2, folic acid), vanilla flavor, and water; (2) The pre-gelatinization process uses a kettled steam jacket, which heats and stirs the mixture of ingredients and cooking water (1: 4) at 70-75 ºC for 4 minutes; (3) The cooked porridge paste is dried using a drum dryer at 120-140 °C, 2.6 bar pressure, and 2 rpm rotation speed; (4) Grinding or flocculating using a disc mill; (5) Uniformity of sizes using a 40 mesh vibrator screen; and (6) Weighing and packaging.

2.2. Criteria and Design of Pilot Plant Scale Instant Porridge Production Line

Pilot plant-scale production line criteria are needed to ensure the production line can operate effectively, produce quality products, and meet food safety requirements. In this case, some of the criteria considered include: (1) production capacity, (2) food safety, (3) product formula and quality, (4) efficiency and productivity, (5) rules and regulatory requirements, and (6) sustainability.

The data include an operation process chart (OPC), a multi-product process chart (MPPC), and a routing sheet to process and obtain results from an instant weaning food production line layout on a pilot plant scale. An operation sequence, raw material inspection, and process steps until the products are produced are all shown in an operation process chart, or OPC. The benefits of using an Operation Process Chart include: (1) Obtaining data on the needs of the type of operation process, machine specifications, production facilities, and the sequence of the process; (2) Obtain data on raw material needs by taking into account efficiency in each element of work operations; (3) obtaining the layout pattern of the material transfer of the flow operation facility and (4) Get alternative improvements to the procedures and work procedures that are being used.

MPPC is a diagram that depicts the process sequence of each component produced and the amount of machine use required from the routing sheet, carried out based on the OPC that has been prepared; this is useful for showing the production relationship between product components, materials, parts, and activities, and analyzing and planning the flow of goods in the production space that is already running or still in the planning stage.

An operation process map requires a routing sheet, starting from the initial stage by identifying. Moreover, it determines the order of machines/equipment and processes that suit their needs and efficiency; this is used to determine the running of the production process of components by using a production process map pattern. Routing Sheets are essential for production supervision because (1) determine the quality of the products made, (2) the time required to work on each production activity, (3) planning the layout of facilities and relocation, (4) calculate the machines needed and the parts that must be prepared to get the final product.

The information that must be present includes the name and number of the part to be made, the working drawing number of the component, the work operation and its operation number, the machine or production equipment used, and the standard time set for each work operation.

The final stage is to create a layout of the instant porridge production line to arrange the location of the tools used during the production process so that they run optimally. Preparing the tool layout aims to minimize cross-contamination between materials and labor. The production flow pattern, which is a visual representation of the sequence of operations in the production process, is based on the results of the routing sheet calculation. It plays a crucial role in ensuring the smooth and efficient flow of production activities.

A descriptive method can describe or describe the flow pattern that can be used for the production of pilot plant-scale instant porridge, taking into account the area of the production space, the layout of the tools, and the machines used in the production process. The production flow patterns used for MSME-scale instant porridge production lines are straight-line flow patterns, zig-zag flow patterns, and U-shaped flow patterns based on the effectiveness of preparing equipment layouts and the capacity of existing production spaces.

3. Results and Discussion

3.1. Instant Porridge Formula

The quality of instant porridge products refers to Indonesian National Standard (SNI) No. 01-7111.1-2005 concerning quality standard requirements for complementary foods for breast milk in the form of instant powder [9]. The results of chemical, physical, microbiological, and sensory analysis of pilot plant-scale instant porridge products are presented in Table 1. The formula of the product includes mocaf flour, tempeh flour, skimmed milk, inulin, sugar, palm oil, micronutrient premix (a mixture of Fe, Zn, vitamin B1, vitamin B2, and folic acid), vanilla flavor, and water [5]. The analysis results indicate that the instant porridge possesses a lower protein content but a higher fat content compared to the instant porridge formulated with sorghum flour and papaya puree, as reported by Surahman et al. [10].

The analysis results of instant porridge products for moisture content, ash, protein, fat, Fe and Zn minerals, and total plate numbers met the Indonesian National Standard. However, carbohydrates that exceed the SNI provisions are due to the influence of the formulation of adding mocaf flour and refined sugar as a source of carbohydrates. Sensory testing of color brightness, aroma, sweetness, smoothness in the mouth, and ease of swallowing, using a hedonic test, was carried out on 30 mothers who have babies aged 6–23 months because mothers are the dominant determinants of the diet in babies. Ethics approval for consent to participate in product sensory test involving 30 respondents, mothers of toddlers, has been aggrement of the Human Ethics Commission at the National Research and Innovation Agency, with ethics approval number 167/KE.01/SK/6/2022 [11].

The overall assessment of sensory on a scale of 6 indicates that the product is preferred. The shelf life of instant porridge has been tested by Herminiati, et al. [12] using the Accelerated Shelf-Life Testing (ASLT) method of the Arrhenius model with protein content parameters, which recommended that packaging with aluminum foil at a storage temperature of 30°C can last 214 days.

Table 1.
Results of pilot plant scale instant porridge analysis

No.	Composition	Analysis results	SNI No. 01-7111.1-2005
1	Moisture content	3.86%	Max. 4.0%
2	Ash content	1.52%	Max. 3.5%
3	Carbohydrate content	77.69%	Max. 50.0%
4	Protein content	8.22%	8.0 – 15.0%
5	Fat content	10.25%	6.0 – 15.0%
6	Fe content	89.19 ppm	Min. 50 ppm
7	Zn content	48.42 ppm	Min. 25 ppm
8	Solubility	46.69 mL/g	-
9	Kamba density	0.528 g/m^3	-
10	Rehydration power	3.59 %	-
11	Color with chromameter	76.45	-
12	Total Plate Count	3.2 x 10^1 CFU/g	Max. 1.0 x 10^4 CFU/g
13	Sensory:		
	Brightness of color	3.70 (rather of bright)	-
	Aroma	3.46 (rather of mild)	-
	Sweetness	4.03 (rather of sweet)	-
	Smoothness in the mouth	4.76 (smooth)	-
	Ease of swallowing	4.96 (easy to swallow)	-

Regulations for instant porridge as a complementary food for breast milk refer to the Regulation of the Food and Drug Supervisory Agency (BPOM) No. 24 of 2020, including the main a complementary food for breast milk category [13]. Testing of the effectiveness of the product has been carried out using experimental animals for models of protein deficiency and protein energy deficiency [5] this is done because it is related to regulations from BPOM, that the safety and adequacy of the nutritional content of the materials used for the manufacture of complementary food staples must be scientifically proven to be able to support the growth and development of infants and children aged 6 (six) to 23 (twenty-three) months.

3.2. Design of Pilot Plant Scale Instant Porridge Production Line

The concept of instant porridge production is based on using tools and equipment that support the production process, namely scale, steam jacket kettle, drum dryer, disk mill, vibrator screen, sealer, and other supporting equipment. The operation process chart of the instant porridge production line is presented in Table 2, and the production process flow scheme is presented in Figure 1.

At the stage of preparing raw materials, all materials used to make instant porridge are prepared according to their respective compositions in the preparation room and scales. The instant porridge formula based on Herminiati, et al. [5] can manufacture instant porridge for stunting prevention. In the preparation room, the ingredients are prepared, weighed, and mixed according to the predetermined composition.

Table 2.
Operation Process Chart (OPC) for the addition of raw materials and supporting materials

Map number	Object name	Machine name	Total times (minutes)
1	Mocaf flour	Digital scales	2
2	Tempeh flour	Digital scales	2
3	Refined sugar	Digital scales	2
4	Skim milk	Digital scales	2
5	Palm oil	Digital scales	2
6	Inulin	Digital scales	2
7	Micronutrient premix	Digital scales	2
8	Vanilla flavor	Digital scales	1
9	Instant porridge ingredient mix	Digital scales	10
10	Instant porridge ingredient mix	Steam jacket kettled	15
11	Instant porridge paste	Drum dryer	120
12	Instant porridge flakes	Disk mill	25
13	Instant porridge powder	Vibrator screen	100
14	Instant porridge powder	Sealer	120

The next stage is cooking and making paste. The mixture of raw materials that have been prepared is then cooked in a steam jacket kettle. The cooking process aims to make the mixture homogeneous and in the form of a paste ready to be dried. The capacity of the steam jacket kettle is adjusted to the capacity of the drum dryer; it can be made per batch with a capacity of 5.55 kg of ingredients per hour or made one way with a cooking capacity of 33.3 kg of ingredients. In this process, the dough is heated with the help of a water heating source at the right temperature to achieve the desired consistency.

Then, after the dough cooks and becomes a paste, it is dried in a drum dryer. Based on previous research, effective drum dryer drying must reduce the material's moisture content by up to 4–5% bb. Before the paste is put into the drum dryer, it is necessary to ensure that the process temperature has been reached; according to research results of Hidayat, et al. [6] the temperature of the drum ranges from 100ºC to 140 °C depending on the rotation speed of the drum. The drum dryer is rotated at an adjusted speed to dry the paste evenly and produce instant slurry flakes.

The following process is grinding with a disc mill. The instant slurry flakes produced from the drum dryer are then further processed using a disc mill. The disc mill reduces the flake's size so that it becomes a finer powder. The disc mill has a predetermined capacity and dimensions and can grind up to 20 kg of instant slurry powder per hour.

After becoming powder, instant porridge powder that has been ground is separated using a vibrator screen. The vibrator screen filters powder particles with the desired mesh size. The screen vibrator used has specifications according to production needs, namely a sieve diameter of 400 mm and a vibration frequency of 1000 N/min.

The final stage is packaging and storage. After the separation process, the instant slurry powder is ready to be packed. The packaged finished products are then stored in a pre-prepared packaging room. The packaging room should include a storage area for ready-to-pack products, packaging materials, and finished products after packaging. This space area must sufficiently store all materials and products neatly arranged. Paying close attention to each piece of equipment's working capacity allows the production process to proceed continuously.

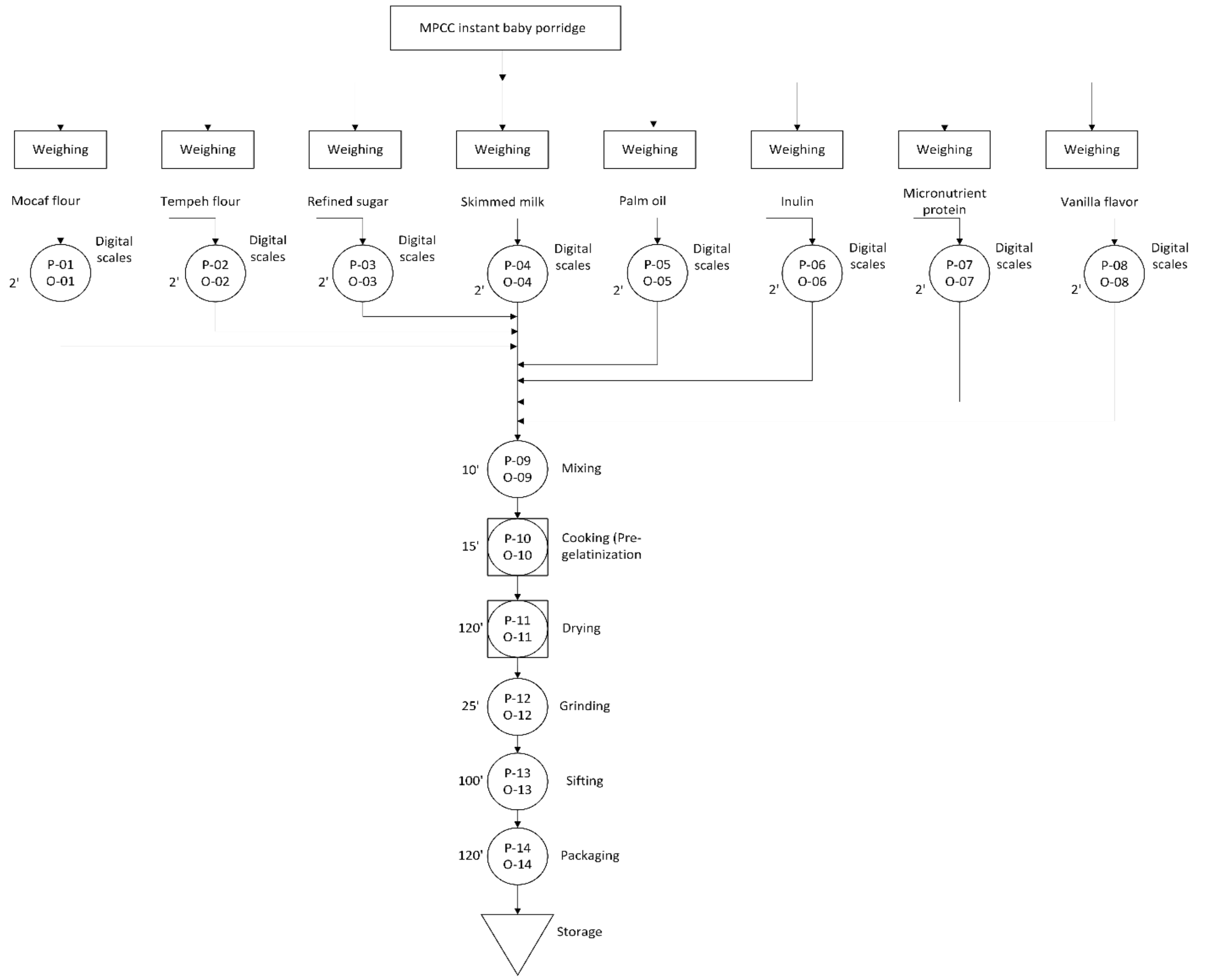

Figure 1.
A multi-process product chart (MPCC) of pilot plant scale instant porridge.

A routing sheet is compiled to determine the number of machines/equipment needed to meet production, taking into account the percentage of scrap, machinery/equipment, and the efficiency of the production site. The number of machines/equipment is determined using the routing sheet method, which considers the machine's capacity. The data was obtained to calculate the number of machines from the production trial, namely the data on the operating time in one process and the % lost product produced. The process order of the routing sheet is based on the process order on the operation map. The results of the routing sheet are presented in Table 3.

Table 3.
Routingsheet instant porridge pilot plant scale.

Process code	Process	Number of machine needed
O - 01	Weighing	1 unit
O - 09	Mixing	1 unit
O - 10	Cooking (Pre-gelatinization)	1 unit
O - 11	Drying	2 unit
O - 12	Milling/flouring	1 unit
O - 13	Sifting	2 unit
O - 14	Packaging	2 unit
Total		10 nit

3.3. Capacity and Dimensions of Production Process Tools

The overall production capacity is calculated based on the working capacity of the main machine for producing instant slurry, the drum dryer. The prototype and specifications of the drum dryer used are presented in Figure 2 and Table 4.

Figure 2.
Drum dryer developed for pilot plant-scale instant slurry production.

Table 4.
Specifications of the drum dryer

Number	Parameter	Description
1	Total dimensions (p × w × t)	1.6 × 1.15 × 2.1 m
2	Drum diameter	500 mm
3	Drum length	400 mm
4	Drum thickness	20 mm
5	Drum material	Cast iron FCD 450 hardened with chromium
6	Power source	Electric motor 2.24 kW, 3 phase
7	Gear box ratio	1 : 50
8	Sprocket ratio	1 : 3
9	Pulley ratio	1 : 3
10	Inverter	YD 101, 3 Phase 400 V
11	Drum rotation speed	0 - 3 rpm
12	Feeding system	Nip
13	Heating source	Electric steamer (9000 W)
14	Capacity	10 kg/batch or 5 kg/hr material input

Based on testing, the drum dryer's yield is about 25% of the paste dough input. 5 kg of paste dough results in 1.25 kg of dry product in flake form, which is ready to be flaked. The drum dryer machine's effective working capacity is 6 hours per day, the daily process capacity is 30 kg of paste dough, and the output of flake products is 7.5 kg per day.

Machines, including a kettled steam jacket, disc mill, and vibrator screen, is needed to support the production process. Steam jacket kettled is a tool used to cook dough (pre-gelatinization) until it forms a paste before being dried using a drum dyer, starting from packing ingredients according to the composition to the initial cooking to make the mixture homogeneous and in the form of a paste (thick). The drum dryer capacity is adjusted to 5 kg of paste per hour. Thus, the minimum capacity of the drying tube is 5 kg of material per batch with a processing time of at most 1 hour or a capacity of 30 kg per batch (for one process per day).

Furthermore, disk mill and vibrator screen are also selected based on capacity and dimensions that suit production needs. The disc mill reduces the size of the flake produced from the drum dryer so that it becomes powder. Meanwhile, the vibrator screen filters powder particles with the desired mesh size. Based on these needs, the specifications of supporting equipment, including steam jacket kettle, disc mill, and vibrator screen, are presented in Table 5.

Table 5.
Specifications of supporting machines for instant porridge production lines.

Name of machines	**Specification**
Steam jacket kettled 	Inner tank volume: 50 liters Inner tank: SS 304 2 mm thick Outer tank (water coat): SS 304 2 mm thick Water heater source: Water heater Electrical panel for temperature control Exhaust unit: 0.5 HP electric motor Rpm motor: 15-20 RPM Dimensi total: 100 × 100 × 80 cm Weight: 40 kg
Disk mill 	Type: FFC-15 Capacity: 20 kg/ Hour Power source: 750 W electric motor, 1 phase Blade: Disc/Disc (2 Units) Diameter rotor: 150 mm Dimensi total: 57 × 31 × 61 cm Weight: 18 kg
Vibrator screen 	Electrical power: 120 W, 1 phase Vibration frequency: 1000 N/min Sieve diameter: 400 mm Engine dimensions: 445 × 400 × 530 mm Weight: 20 Kg

3.4. Effective Production Scenarios

Each process is analyzed to ensure that there is no bottleneck in the production line, making each production unit's work more efficient. Table 6 presents several proposed scenarios. Based on Table 6, it can be seen that the compelling scenario to complete the production of instant porridge in one working day is scenario 3, where in this scenario, the dough cooking process using a steam jacket kettle is carried out in 3 batches with the capacity of each batch being 10 kg of dough. Dough cooking is carried out in three stages, so the drying process can be carried out continuously because the drum dryer can produce 5 kg of dough per hour. With a gradual process like this, the dough is held briefly and does not accumulate at the beginning, as in scenarios 1 and 2. The output from the drum dryer is about 25% of the weight of the dough, so from 5 kg of dough obtained an instant porridge product in the form of flakes of about 1.25 kg, which is then processed in stages as scenario 3. The process includes size reduction using a disc mill, sifting using a vibrator screen, and the final stage, packaging.

Table 6.
Production process scenarios.

Scenario	Process unit	Work hours (hour)								Notes
		1	2	3	4	5	6	7	8	
1	Mixing and cooking (Steam jacket kettle)	30.00 kg								
	Drum dryer				5.00 kg	5.00 kg	5.00 kg	5.00 kg	5.00 kg	5.00 kg left
	Disk mill					1.25 kg	1.25 kg	1.25 kg	1.25 kg	2.50 kg left
	Vibrator screen					1.25 kg	1.25 kg	1.25 kg	1.25 kg	2.50 kg left
	Packaging					1.25 kg	1.25 kg	1.25 kg	1.25 kg	2.50 kg left
2	Mixing and cooking (Steam jacket kettle)	15.00 kg			15.00 kg					
	Drum dryer			5.00 kg	5.00 kg	5.00 kg	5.00 kg	5.00 kg	5.00 kg	Finished
	Disk mill				1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg left
	Vibrator screen				1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg left
	Packaging				1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg left
3	Mixing and cooking (Steam jacket kettle)	10.00 kg		10.00 kg		10.00 kg				
	Drum dryer		5.00 kg	5.00 kg	5.00 kg	5.00 kg	5.00 kg	5.00 kg		Finished
	Disk mill			1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg	Finished
	Vibrator screen			1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg	Finished
	Packaging			1.25 kg	1,25 kg	1.25 kg	1.25 kg	1.25 kg	1.25 kg	Finished

3.5. Production Line Layout

In a competitive marketplace, manufacturing firms must deliver cost-efficient products, which can be achieved by minimizing production expenses and enhancing operational efficiency. Effective facility planning plays a crucial role in substantially reducing a company's operating costs [14]. The layout of machinery/equipment is a procedure for arranging machinery/equipment facilities by utilizing the area optimally, which helps support the smooth production process [15] to have the fastest flow of materials at the lowest cost [16]. Layout refers to the selection of locations, processes, functions or activities that are part of the operation of a facility [17]. The layout of the facility determines the general flow of workers and material movements, which significantly impacts operating efficiency. Signs of a good layout include a planned flow pattern, minimum moving between operations, minimum moving distance, minimum removing, and as short as possible walking between production operations. Previous studies have shown that facility layout can minimize total material handling costs [18] increase productivity [19] and improve operator performance [20].

The next step is to create a layout of the instant baby porridge production line on a pilot plant scale. The preparation of machinery/equipment used in production is based on food processing practices in the production room. The following figure presents an alternative layout for designing an instant porridge production line on a pilot plant scale that can be applied.

Based on Figure 3, pilot plant-scale instant baby porridge production can use three layout types to arrange machinery/equipment and room layouts with straight line flow patterns, zigzag flow patterns, and U-shaped flow patterns. In Figure 3A, the flow pattern is arranged based on a straight line, used when the production process is not too long, relatively simple and contains only a few components or pieces of production equipment. This flow pattern is very effective in the production process of instant baby porridge on a pilot plant scale because the arrangement of machinery/equipment is arranged straight from the beginning to the end of the production process so that it can minimize contamination from the environment and workers. The arrangement of the tool in a straight line can provide a short distance between processes, and the process goes straight according to the machine's order.

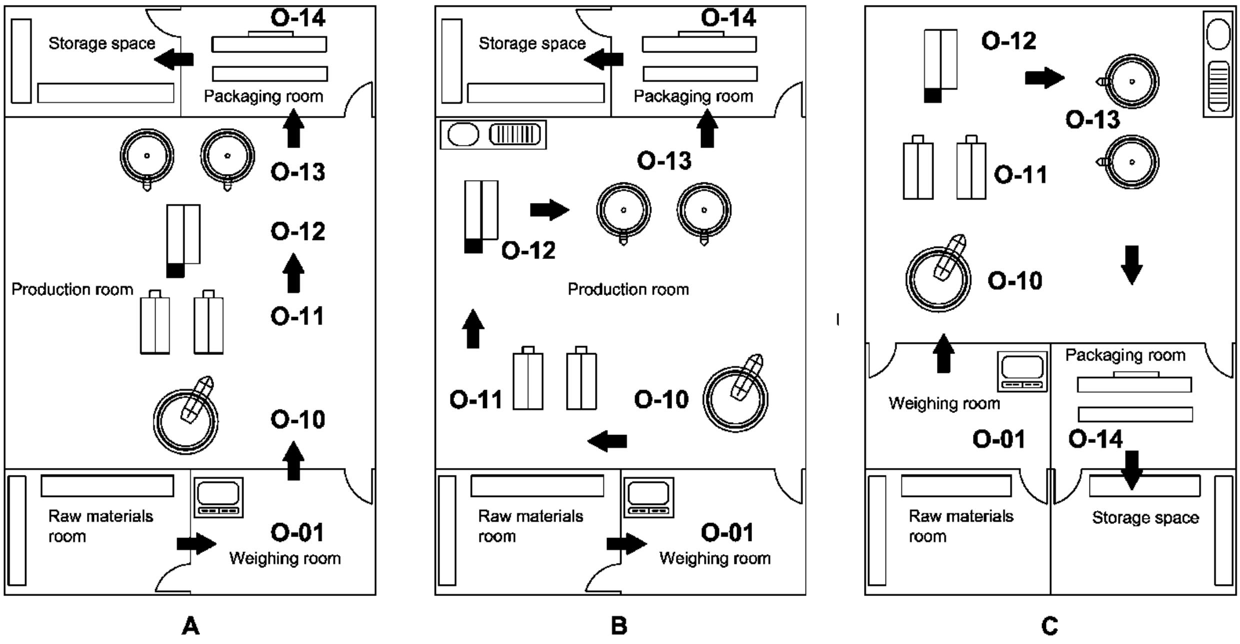

Figure 3.
A. Straight line flow pattern production line layout, B. zig-zag flow pattern production line layout, C. U-shaped flow pattern production line layout.

Figure 3B arranges the flow pattern based on a broken line or *a zig-zag* flow pattern (*S-shaped*). This flow pattern is effectively applied to long process flows compared to the area available for production space. The material flow is deflected to increase the length of the existing flow line and economically overcome any limitations of the area and size of the existing production room building. This flow pattern can produce instant porridge on *a pilot plant scale* because the preparation of materials in a *zig-zag* manner can make the existing room more efficient and control the distance between one machine and another. The tools are arranged in a *zig-zag pattern* according to the production process flow, from weighing raw materials to storing finished products; this is done to avoid cross-contamination between materials from one process to the next. The placement of tools according to the production flow aims to make it easier for workers to move production products from one process to the next because the distance from one process to the next is short. The packaging room is designed separately from the production room to avoid cross-contamination between the final product and the product that is still in process in the production room. The packaging room is designed to be closed and separate from the production room so that the cleanliness and safety of the food are guaranteed.

In Figure 3C, the flow pattern is arranged to form the letter U or *the U-shaped flow pattern; t*his pattern is used when it is desired that the end of the production process will be in the exact location as the beginning of the production process; this will facilitate the use of transportation facilities and supervision for when entering and exiting materials to the production room. This flow pattern effectively produces pilot plant-scale instant baby porridge because the material flow line is short enough. However, the flow of material displacement is relatively long, so the time used is longer when compared to the flow pattern arranged in a straight line and *zig-zag.*

4. Conclusion

The preparation of the production line layout with straight, zig-zag (S-shaped) and U-shaped flow patterns can be applied to the production of instant porridge on a pilot plant scale. The instant porridge production line has been developed by considering the aspects of capacity, availability of materials and production performance. The production line generally consists of 5 central process units: steam jacket, kettle, drum dyer, disc mill, vibrator screen and packaging. The most effective scenario for producing instant porridge with an output capacity of 7.5 kg per day (8 working hours) is scenario 3, where the cooking process with a steam jacket kettle is carried out three times. Developing production lines with the suitable capacity for SMEs can provide significant economic and social benefits. The development of effective production lines will increase the productivity and competitiveness of SMEs, which has the potential to increase income and local economic development. In addition, by increasing the accessibility of nutritious food, SMEs can also play an active role in building public awareness about the importance of balanced nutrition and encouraging better behavioural changes related to diet. This research is expected to be applied to develop an SME-scale instant porridge production line that effectively supports stunting prevention.

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