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Editorial Preface

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It is our great pleasure to present the Volume 3 Number 2 Advance Sustainable Science, Environmental Engineering and Technology (ASSET). This issue includes seven manuscripts. Crisostomo's article: *3D Printing Applications in Agriculture, Food Processing, and Environmental Protection and Monitoring*. This paper presents a mini review of the use cases of 3D printing in the fields of agriculture, food processing, and environment protection and monitoring. Macaraeg's article: *Establishment of an Academic Makerspace at the Bataan Peninsula State University: Prospects and Challenges*. Their study summarizes the best practices of some Academic Makerspaces in the United States and in the Philippines including their facilities. Dinata's article: *Correlation of Sex Ratio and Population of Callosobruchus chinensis L. (Coleoptera: Bruchidae) in Mung Beans.* This study aims to determine the correlation between the sex ratio of the population and its development in *C. chinensis* and to see its preference for mung beans. Rakasiwi's article*: Utilization of E-money for School Payments Using Web-Based RFID Sensors*. In this work they developed an application that uses a school student card as a personal identity in searching for data that will be linked to a web as a basis. Kusumo's article: *Information System Supply Chain Management with FIFO Pertetual Method*. This study aims to improve inventory management and report presentation by implementing a Supply Chain Management (SCM) information system using the Pertetual FIFO method at PT. Von Mustika.Sussolaikah's article: *Market Basket Analysis for Determination of Consumer Behavior at XYZ Stores Using R Programming*. The authors conducted research on consumer behavior by using one of the data mining techniques, namely market basket analysis. Nurafifah's article: *Activity of Moringa oleifera seed ethanolic extract against E. coli*. This study found out the ability of *M. oleifera* seed ethanolic extract as antibacterial agent against *E. coli*.

We thank all of the 13 authors affiliated from Bataan Peninsula State University, Philippines; Universitas Sains dan Teknologi Komputer, Brawijaya University, Universitas PGRI Madiun, Indonesia who have contributed to this issue. We believe that all the papers published in this issue will have great influence on the science, environmental engineering and technology.

October 2021
Asst. Prof. Mega Novita
Asst. Prof. Rizky Muliani Dwi Ujianti

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3D Printing Applications in Agriculture, Food Processing, and Environmental Protection and Monitoring

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Abstract. 3D Printing, more formally known as Additive Manufacturing, is already being applied in many different applications. This paper presents a mini review of the use cases of 3D printing in the fields of agriculture, food processing, and environment protection and monitoring. Specifically, the paper discusses the different materials used in 3D printing of parts, the different printing technologies employed in the process, as well as the application prospects. PLA and ABS thermoplastics are the most common materials used for 3D printing in the field of agriculture as they are relatively cheap and easy to print. The direct extrusion of food helps people with swallowing difficulties increase their food intake as well as customize their diet. As for the environment, applications in water desalination and air quality monitoring are among the relevant applications of 3D printing presented in this paper.

Keywords: 3D Printing, Additive Manufacturing, Agriculture, Food, Environment

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1. Introduction

3D printing has been garnering increasing attention from different industries for its revolutionary impact in the field of manufacturing. It is set to gain mass adoption for its sustainable and efficient system of creating a variety of objects layer by layer using a 3D printer [1]. This technology greatly reduces waste and lead time in contrast to conventional manufacturing which includes subtractive manufacturing where a portion of a material is removed/subtracted from its greater part to produce a desired by-product. One of its advantages over formative manufacturing is its ability to produce complex shapes. The burden of high costs from traditional manufacturing is also considerably minimized through additive manufacturing [2].

Additive manufacturing has significant real-world applications in different fields such as in construction, electronics, automotive, personal protective equipment, astronomy, oceanography, military, and many others [3-9]. Moreover, additive manufacturing is becoming more prevalent in industrial applications requiring high performance such as in rapid prototyping, rapid tooling, rapid manufacturing [1,10,11,12,13,14], advanced electronics [4], medical applications [5], water filtration and desalination [14,15], and others. In agriculture, 3D printing finds most utility in the production of farming tools [16] and replacement parts [17] without greatly compromising their quality. The food industry mainly uses 3D printing to hasten to modify personal nutrition [18] as well as to help people with swallowing problems increase their food intake [19]. As for the environment, the production of recycled filaments [20] and of the parts of equipment used for air quality monitoring [21] and wastewater treatment device [22] are the relevant use cases of additive manufacturing.

There are a variety of materials and printing technologies associated with 3D printing. Fused deposition modeling (FDM) is one of the most popular 3D printing technology as it offers consumer-grade materials/filaments such as acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA) thermoplastic [1]. Food can also be directly extruded from the printer nozzle as it is built layer by layer or it can be cast in a mold— as in the case for 3D printed puree [23]— created by a 3D printed pattern.

The recognition of the uses of 3D printing in many fields and industries is the future of manufacturing. It is a revolutionary technology where efficiency and sustainability go hand in hand that greatly improves our way of creating and producing things that have relevant use cases in a myriad of industries and fields. This review paper will provide an overview of the applications of 3d printing in the areas of agriculture, food processing, and environment protection/monitoring, as well as the technologies and materials being used.

2. Overview of Additive Manufacturing

3D printing generally goes through a 5-step process. First, a 3D model is generated with the use of computer-aided design (CAD) software. Such model is then converted into a Standard Tessellation Language (.STL) file so that a 3D printer can read its surface geometry. Subsequently, the model is sliced into multiple layers in order to feed printing instructions to the 3D printer. The model then materializes in the additive manufacturing system (3D printer) where the object is extruded layer by layer. Finally, post-processing is done in order to enhance the print quality of the 3D printed object [1].

There are many kinds of 3D printing technologies with different ways of manufacturing systems. Besides the extrusion-based FDM, stereolithography (SLA) is also a common 3D printing technology where photocurable resin is often used as the material. Compared to SLA, digital light processing (DLP) uses a projected digital image instead of laser which allows the printing process to proceed at a significantly faster rate. Selective laser sintering (SLS) uses laser as the heating source that selectively sinters the powder polymer such as resin or metal to create a 3D printed model. Other 3D printing methods include multi jet fusion (MJF), electron beam melting (EBM), direct metal laser sintering (DMLS), laminated object manufacturing (LOM), and others [1].

ABS and PLA thermoplastics are the widely used materials in 3D printing as they are associated with the consumer-level FDM printing technology [1]. These filaments are available in different colors and are recognized for their strength, stiffness, printability, cost-effectiveness, and other favorable properties that make them desirable materials for additive manufacturing [24]. Other materials include resin that presents high quality prints through smooth and transparent surfaces. Powders in the form of polyamide nylon is also commonly used for highly detailed and flexible printed objects [25]. Precious metals such as gold, silver, and brass can be used for jewelry applications [26].

3. 3D Printing Applications in Agriculture

3.1. Printing Technology and Materials

FDM is the commonly utilized printing technology in the production of different tools and equipment used in the field of agriculture. Thermoplastic, notably PLA and ABS, have found significant use cases in the production of farming tools such as sprinklers [27] and hose splitters used for irrigation [16], spare machine parts such as the corn auger [28] and gears [29], as well as in seed sowing equipment [30]. Farmers can also create customized tools using PLA such as a fruit picker and a shovel with the material being biodegradable and recyclable [16]. While these thermoplastics may differ slightly with their properties like stiffness and heat resistance, they are the most commonly used filaments in 3D printing owing to their (low) cost and straightforward use in 3D printing. Table 1 summarizes the application, material, and 3D printing techniques used in the field of agriculture.

3.2 Irrigation and Water Management

Most of irrigation and water management equipment could be manufactured using 3D printing; the garden hose splitter/adapter shown in Figure 1 is one such example [16]. The design of this supplementary equipment could be modified to allow multidirectional flow of water from a garden hose. Thermoplastic is the commonly used material to produce 3D printed objects and parts that can greatly help in water distribution systems in farms by replacing their costly, original parts. In this application, the PLA thermoplastic is the printing material used through fused deposition modeling.

The 3D printed spigot shown in Figure 2 is especially made for a 5 gallon bucket [16]. It is made of PLA thermoplastic through FDM. With additive manufacturing, the size and dimension of such tool can be customized accordingly with customized design and attachments such as a contour that fit the particular water container. The technology offers efficient and cost-effective production of these parts.

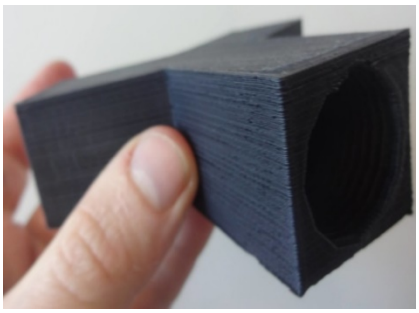

Figure 1. 3D printed garden hose splitter [16]

Figure 2. 3D printed spigot [16]

3.3 Urban Farming

While there are numerous innovations for optimized bulk harvesting, 3D printing can add value through a simple mechanism of clawing fruit that gathers high-hanging fruits without having to use ladders. The 3D printed parts of the tool can be incorporated with conventionally manufactured components like the wood handle, springs, and screws in order to make up the tri-claw fruit picker, as shown in Figure 3 [16]. Polylactic acid (PLA) proves useful in the material make-up of the parts created through fused deposition modeling as it is biodegradable and recyclable. This avoids unnecessary waste generated from conventional manufacturing, thereby promoting sustainability.

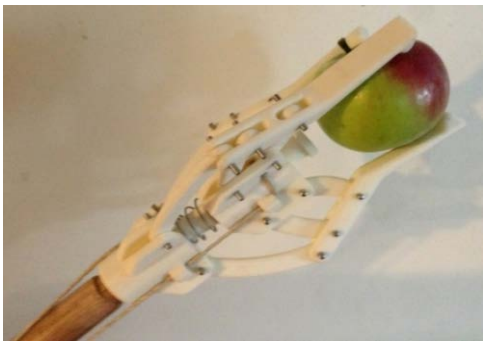

Figure 3. 3D Printed Fruit Picker [16]

Figure 4. Meat Slurry Puree [23]

Table 1. Applications, materials, and 3D printing techniques used for 3D printing in agriculture.

3D Printed Part	Application	Material/Filament	3D Printing Technique	Reference
Sprinkler	Irrigation	ABS	Fused Deposition Modeling	[27]
Hose splitter	Irrigation	PLA	Fused Deposition Modeling	[16]
Fruit picker	Urban Farming	PLA	Fused Deposition Modeling	[16]
Shovel and handle	Urban Farming	PLA	Fused Deposition Modeling	[16]
Packer bottom	Testing Equipment	ABS	Fused Deposition Modeling	[30]
Spigot	Water Management	PLA	Fused Deposition Modeling	[16]
Corn Auger	Spare Part	PLA	Fused Deposition Modeling	[28]
Gear	Spare Part	Polymeric material	Fused Deposition Modeling	[29]

3.4 Prospects

3D printing can stimulate youth entrepreneurship by designing and printing their own models and potentially taking advantage of the technology as an enterprise. Such businesses can also bring about collaboration among professional designers, entrepreneurs, and most especially farmers who are the primary beneficiaries of additive manufacturing in the field of agriculture. Research and development can be implemented to further increase manufacturing efficiency and quality as well as prospective materials that can be used alternatively for commonly established 3D printing materials such as thermoplastics [31]. With the advent of large format 3d printers, large parts with at least 1 cubic meter in size, can now be produced, which further expands the use cases of 3d printing. It is expected that in the future, other 3d printing technologies other than FDM will also be utilized.

4. 3D Printing Applications in Food

4.1 Printing Technology and Materials

Extrusion-based 3D printing, also known as FDM, is the most common printing technology in the food sector. 3D printing allows rapid manufacturing such as in making a cake layer by layer using a cake decorating robot [32]. Purees manufactured using 3D printing are mixed with a certain amount of thickening additives such as gelatin for the meat slurry [23] and pectin for the fruit-based snack in order to increase its print quality [18]. Mashed potato is printed from potato flakes with gelatinized starch, known as an ideal ingredient for the manufacturing of finished products for its lesser requirement in post-processing [33]. Vegetables such as carrots, peas, and corn can also be 3D printed as they are relatively easy to prepare and are inexpensive food inks [19]. Pizza [34], pasta [23], and dessert [35] can also be created directly using extrusion-based 3D printing. Table 2 summarizes the application, food ink, and 3D printing techniques used for the food sector.

4.2 People with Dysphagia

The 3D printed meat slurry shown in Figure 4 [23] is added with 100g of water and 40g of gelatin powder for better print quality. Moreover, it is designed in order to help people with dysphagia— a condition where there is difficulty in swallowing— to increase their food intake. The mixture of gelatin with the cooked meat slurry resulted in good print quality of the 3D printed food. 3d printing provides a novel way to produce instant and ready-to-eat food which can simulantaneously help consumers spend less than if the food is bought (physically) in a market. 3d printing also helps in devising a diet plan because the exact nutrional components can be manipulated before printing. Vegetables can also be additively manufactured as is the case for the 3D printed vegetables that are designs of garden peas, carrots, and corn. The selection of food ink with different nutritional components is enabled while maintaining the food's visual appeal for dysphagic patients to perceive such 3D printed food as no less different from tradionally-prepared food. Such extruded food are made to be soft in the pre-extrusion phase of the 3D printing process so that they can be made more chewable [19].

4.3 Personalized Nutrition

Personalized nutrition is also made possible with 3D printing. One such example of this is the 3D printed fruit-based puree snack made for the consumption of children aged 3-10 years old. It is made of banana, lemon juice, dried non-fat milk, white canned beans, and dried mushrooms. The snack is designed to provide a controlled amount of energy, iron, calcium, and vitamin D required for children at these age levels. It is produced through an extrusion-based printing technology. Pectin was found to be useful in this application as it enabled the 3D printing of puree, which is a gelling agent commonly used in the food industry. Using such food material to be combined in the pre-extrusion phase resulted in good printing quality [18].

4.4 Prospects

3D printing of food still has a lot of room for growth in terms of maintenance, scale of production, and the quality of the manufactured food. In order to increase printability of food, thickening agents such as starch and gelatin can be used. Food 3D printers have printing systems which often result in laborious maintenance which require them to be manually and carefully cleaned. This could be aided by some sort of automated cleaning system within the 3D printer. For food materials that can be directly printed, future research can show feasible food that can also be made through additive manufacturing. [23].

Table 2. Applications, Materials, and 3D Printing Techniques Used for Additive Manufacturing in Food.

3D Printed Food	Application	Material/Filament	3D Printing Technique	Reference
Cake	Rapid Manufacturing	Frosting	Extrusion-based 3D printing	[32]
Meat Slurry	Increase food intake	Gelatin and meat	Extrusion-based 3D printing	[23]
Vegetables	Increase food intake	Carrots, peas, and corn	Extrusion-based 3D printing	[19]
Fruit-based snack	Personalized Nutrition	Banana, lemon juice, etc.	Extrusion-based 3D printing	[18]
Pizza	Rapid Manufacturing	Dough and tomato sauce	Extrusion-based 3D printing	[34]
Pasta	Rapid Manufacturing	Traditional pasta	Extrusion-based 3D printing	[23]
Chocolate	Customized dessert	Chocolate	Extrusion-based 3D printing	[35]

5. 3D Printing Applications in Environment

5.1 Printing Technology and Materials

Selective laser sintering (SLS), Fused deposition modeling (FDM), and vertical 3D printing are the printing methods used for the fabrication of the parts of equipment and objects for the environmental applications of 3D printing. For the air quality monitoring device called "nEMos," thermoplastic in the form of PLA is used for its lightweight property, enabling the device to be carried anywhere for air quality testing [21]. The 3D printed biocarrier is made of nylon that has excellent mechanical properties and straightforward processing attribute [17]. This property of nylon helps significantly in wastewater management. Graphene is the material of choice for the 3D printed evaporator as it is known to have high molecular barrier ability [36]. The artificial coral reef is implied to be 3D printed out of limestone which is mainly composed of calcium carbonate ($CaCo_3$), the natural chemical compound present in naturally existing coral reefs. This material is practically insoluble in water and helps in building other blocks of the reef structure that provide food and shelter for life under water [37]. Other environmental applications of 3D printing include ceramic filters for water treatment [38], carbon anode for alternative energy sources [39], and fiber mesh for deicing [40]. Table 3 summarizes the application, material, and 3D printing techniques used for environmental applications.

5.2 Air quality monitoring

The 3D printed case shown in Figure 5 [21], houses the nano environmental monitoring system (nEMoS) device that is used for calculating the Indoor Environmental Quality (IEQ), which is a measure of the air quality of the environment regarding the health and well-being of the occupants in a particular place. The case is made out of PLA thermoplastic that requires less energy to be produced and is sourced out of renewable resources such as corn starch, making it one of the most sustainable materials in the market [21].

Figure 5. 3D printed case for nEMos [21]

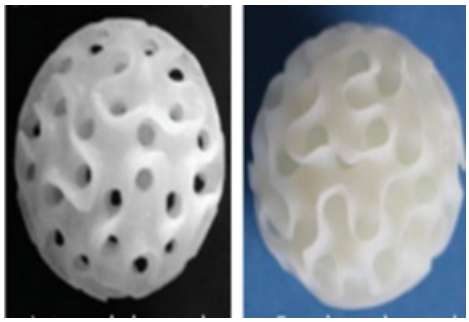

Figure 6. 3D printed biocarriers [14]

5.3 Water Treatment

As previously reported by Tijing et al., 3d printing may be used in water desalination, membrane separation and water purification applications [36]. 3D-printed solar absorbers using the solar-driven interfacial water evaporation (SWE) to produce clean water has also been reported by their group [15]. The 3D printed bio-carriers modelled to the microstructure of fullerene, as shown in Figure 6 [14], aims to improve general performance and organic matter removal of biofilm reactors through specialized structures. It is manufactured through the SLS 3D printing technology. The material used to manufacture this device is a specific type of nylon that is easy to process. 3d printing allows more freedom in the design of the device's structure than in the manufacturing of commercially available bio-carriers.

3D printing presents a possible solution for shortage of clean water through desalination using a 3D printed jellyfish-like evaporator. It is manufactured using vertical 3D printing technology. Its material is composed of graphene which has remarkable properties such as high electrical conductivity and mechanical strength, in this case the most relevant being the material's high molecular barrier abilities. 3D printing allows prototyping and fabrication of photothermal materials such as graphene with desirable properties for solar steam evaporation (SSE) and with designed architecture. [37]

5.4 Artificial Habitat

The artificial coral reef is created by the company XtreeE for synthetic habitat of aquatic life. It is manufactured using a large-scale industrial printer that employs fused deposition modeling, with the material having biomimetic and porous properties resembling the coral itself. 3D printing allows the immediate replacement of coral reefs which can be susceptible to disintegration due to many undesirable aquatic factors such as the warming of the oceans that leads to the proliferation of carbon dioxide in the water, consequently endangering the survival of coral reefs due to acidification [38]

5.5 Prospects

As far as sustainable manufacturing is concerned, 3D printing is top-notch. However, the efficiency of 3D printing systems and the scaling-up of the printing process are still subject to improvement. Prospective materials with desirable properties are yet to be considered in future research. As for well-established materials for 3D printing, printing resolution and accuracy can also be made advanced through further research. [37]

Table 2. Applications, Materials, and 3D Printing Techniques Used for Additive Manufacturing for the Environment

3D Printed Object	Application	Material/Filament	3D Printing Technique	Reference
Case	Air quality monitoring	PLA	Fused deposition modeling	[21]
Bio-carrier	Water treatment	Nylon	Selective laser sintering	[37]

Evaporator	Water treatment	Graphene	Vertical 3D printing	[37]
Coral reef	Artificial habitat	Limestone	Fused deposition modeling	[38]
Clay ceramic	Water treatment	Clay	Extrusion-based 3D Printing	[39]
Anode	Energy source	Carbon	3D printing	[40]
Mesh	Turbine deicing	Carbon fiber	Extrusion-based 3D printing	[41]

6. Conclusion

3D printing is now being widely used in various applications. From manual labor to the creation of machines that help us manufacture the products that we consume and the things that have practical applications, additive manufacturing enables the creation of these as we channel our ideas from the digital to the tangible. With this technology, we can save time and capital which would otherwise be allocated with the conventional methods of manufacturing that often go through lengthy and convoluted processes. It helps us adhere to sustainable and efficient manufacturing as it constantly finds useful applications in many different industries and fields. This paper presented some use cases of 3D printing in the fields of agriculture, food processing, and environment protection and monitoring. Specifically, the paper discussed the different materials used in 3D printing of parts, the different printing technologies employed.

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References:

[1] J. R. C. Dizon, A. H. Espera, Q. Chen, and R.C. Advincula, "Mechanical Characterization of 3D-printed polymers," *Additive Manufacturing*, pp. 44–67, 2018.
[2] J. R. C. Dizon, A. D. Valino, L. R. Souza, A. H. Espera, Q. Chen, and R. C. Advincula, "3D printed injection molds using various 3D printing technologies," *Materials Science Forum*, vol. 1005, pp. 150–156, 2020.
[3] All3DP: "3D Printed House: 20 Most Important Projects," 2020. Accessed on: October 18, 2021. [Online] Available: https://all3dp.com/2/3d-printed-house-3d-printed-building/
[4] A.H. Espera, J.R.C. Dizon, Q. Chen, and R.C. Advincula, "3D-printing and advanced manufacturing for electronics," *Progress in Additive Manufacturing*, 2019.
[5] R. C. Advincula, J. R. C. Dizon, Q. Chen, I. Niu, J. Chung, L. Kilpatrick, and R. Newman, "Additive manufacturing for COVID-19: Devices, materials, prospects, and challenges." *MRS Communications*, vol. 10, issue 3, pp. 413–427, 2020
[6] Z. Al-Dulimi, M. Wallis, D. K. Tan, M. Maniruzzaman, and A Nokhodchi, "3D printing technology as innovative solutions for biomedical applications," *Drug Discovery Today*, vol. 26, issue 2, pp. 360–383, 2021.
[7] J. Y. Wong, "3D printing applications for space missions," *Aerospace Medicine and Human Performance*, vol. 87, issue 6, pp. 580–582, 2016.
[8] J. Mohammed, "Applications of 3D printing technologies in oceanography." Methods in Oceanography. vol. 17, p. 97, 2016.

[9] 3D Print: "3D Printing in the Military," 2017. Accessed on October 18, 2021. [Online]. Available: https://3dprint.com/165561/3d-printing-in-the-military/
[10] J. R. R. Diego, D. W. C. Martinez, G. S. Robles, and J. R. C. Dizon, "Development of Smartphone-controlled Hand and Arm Exoskeleton for Persons with One-Arm Disability (SCHAX)," *Open Engineering*, vol. 11, issue 1, pp. 161–170, 2021.
[11] J. R. C. Dizon, C. C. L. Gache, H. M. S. Cascolan, L. T. Cancino, and R. C. Advincula, "Post-processing of 3D-printed Polymers," *Technologies*, vol. 9, issue 3, p. 61, 2021.
[12] A. D. Valino, J. R. C. Dizon, A. H. Espera, Q. Chen, J. Messman, and R. C. Advincula, "Advances in 3D printing of thermoplastic polymer composites and nanocomposites," *Progress in Polymer Science*, vol. 98, 2019.
[13] J. R. C. Dizon, A. D. Valino, L. R. Souza, A. H. Espera, Jr., Q. Chen, and R. C. Advincula, "3D-printed molds and materials for injection molding and rapid tooling applications," *MRS Communications Prospectives Journal*, vol. 9, issue 4, 2019.
[14] Y. Dong, S. Q. Fan, Y. Shen, J. X. Yang, P. Yan, Y. P. Chen, J. Li, J. S. Guo, X. M. Duan, F. Fang, and S. Y. Liu, "A Novel Bio-carrier Fabricated Using 3D Printing Technique for Wastewater Treatment," Scientific Reports, vol. 5, no. 12400, 2015.
[15] L. D. Tijing, J. R. C. Dizon, G. G. Cruz Jr., "3D-Printed Absorbers for Solar-Driven Interfacial Water Evaporation: A Mini-Review," *Advance Sustainable Science, Engineering, and Technology*, vol. 3, no. 1, 2021.
[16] J. M. Pearce, "Applications of Open Source 3-D Printing on Small Farms," *Organic Farming*, vol. 1, issue 1, pp 19–35, 2015.
[17] E. O. Podchasov, "Design and Technological Features of 3D-Printing Usage in Agricultural Machines Gearings Repair," *International Journal of Mechanical Engineering and Robotics Research*, vo. 10, no. 1, pp. 32–37, 2021.
[18] A. Derossi, R. Caporizzi, D. Azzollini, and C. Severini, "Application of 3D printing for customized food. A case on the development of a fruit-based snack for children," Journal of Food Engineering, vol. 220, pp 65–75, 2018.
[19] A. Pant, A. Y. Lee, R. Karyappa, C. P.Lee, J. An, M. Hashimoto, U. X. Tan, G. Wong, C. K. Chua, & Y. ZhanG, "3D food printing of fresh vegetables using food hydrocolloids for dysphagic patients." *Food Hydrocolloids*, vol. 114, p. 106546, 2021.
[20] M. I. Mohammed, D. Wilson, E. Gomez-Kervin, L. Rosson, and J. Long, "EcoPrinting: Investigation of Solar Powered Plastic Recycling and Additive Manufacturing for Enhanced Waste Management and Sustainable Manufacturing," in 2018 *IEEE Conference on Technologies for Sustainability, SusTech*, pp 1-6, 2019.
[21] F. Salamone, L. Belussi, L. Danza, M. Ghellere, and I. Meroni, "Design and development of nEMos, an all-in-one, low-cost, web-connected and 3D printed device for environmental analysis," *Sensors*, vol. 15, issue 6, pp. 13012-13027, 2015.
[22] M. J. Martín de Vidales, A. Nieto-Márquez, D. Morcuende, E. Atanes, F. Blaya, E. Soriano, and F. Fernández-Martínez, "3D printed floating photocatalysts for wastewater treatment," *Catalysis Today*, vol. 328, pp. 157–163, 2019.
[23] C. Liu, C. Ho, and J. Wang, "The development of 3D food printer for printing fibrous meat materials," IOP Conference Series: Materials Science and Engineering, vol 284, issue 1, 2018.
[24] Markforged: "PLA vs ABS vs Nylon," 2021. Accessed on: October 18, 2021. [Online]. Available: https://markforged.com/resources/blog/pla-abs-nylon
[25] Sharretts Plating Company: "What Materials are Used for 3D Printing?" 2017. Accessed on: October 18, 2021. [Online]. Available: https://www.sharrettsplating.com/blog/materials-used-3d-printing/

[26] i.materialise: “Metals 3D Printing.” Accessed on: October 18, 2021. [Online]. Available: https://i.materialise.com/en/3d-printing-materials/metals#preciousMetals
[27] Proximity Designs: “insert title,” year. Accessed on October 18, 2021. [Online]. Available: https://proximitydesigns.org/service/farm-tech/
[28] Garuda 3D: “3D Printing in Agriculture,” 2021. Accessed on October 18, 2021. [Online]. Available: https://garuda3d.com/3d-printing-in-agriculture
[29] E. O. Podchasoy, “Designd and Technological Features on 3D-Printing Usage in Agricultural Machines Gearings Repair,” *International Journal of Mechanical Engineering and Robotics Research*, vol. 10, issue 1, pp. 32–37, 2021.
[30] T. E. Halterman, “3D Printing Helpds Test Crop Seeding System,” 2015. Accessed on October 18, 2021. [Online]. Available: https://3dprint.com/48469/3d-printing-groundbreaking/
[31] Technical Center for Agricultural and Rural Cooperation: “Exploring the potential of 3D printing for agriculture,” 2017. Accessed on October 18, 2021. [Online]. Available: https://www.cta.int/en/blog/all/article/exploring-the-potential-of-3d-printing-for-agriculture-sid0e875bb2c-478a-4577-975b-a8197d441ef3
[32] M. Wolf, “3D Food Printing Startup BeeHex Debuts a Cake Decorating Robot,” 2019. Accessed on October 18, 2021. [Online]. Available: https://thespoon.tech/beehex-ships-hi-volume-cookie-cake-decorating-robot/
[33] Z. Liu, B. Bhandari, S. Prakash, and M. Zhang, “Creation of internal structure of mashed potato construct by 3D printing and its textural properties,” *Food Research International*, vol. 111, pp. 534–543, 2018.
[34] The Conversation: “Would you eat a 3D printed pizza?” year. Accessed on: October 18, 2021. [Online]. Available: https://theconversation.com/would-you-eat-a-3d-printed-pizza-70335
[35] Z. Liu, M. Zhang, B. Bhandari, Y. Wang, “3D printing: Printing precision and application in food sector,” *Trends in Food Science and Technology*, vol. 69, pp. 83-94, 2017.
[36] L. D. Tijing, J. R. C. Dizon, I. Ibrahim, A. R. N. Nisay, H. K. Shon, R. C. Advincula 3d printing for membrane separation, desalination and water treatment, Applied Materials Today, vol. 18, 100486, 2020, https://doi.org/10.1016/j.apmt.2019.100486.
[37] F. Guo, G. Silverberg, S. Bowers, S. P. Kim, D. Datta, V. Shevoy, and R. H. Hurt, “Graphene-based environmental barriers,” *Environmental Science and Techonology*, vol. 46, issue 14, pp. 7717-7724, 2012.
[38] 3D Natives: “The 12 Initiatives that Combine 3D Printing and Sustainability,” 2019. Accessed on: October 18, 2021. [Online]. Available: https://www.3dnatives.com/en/3d-printing-sustainability-220420194/#!
[39] A. V. O. Akowanou, H. E. Deguenon, L. Groendijk, M. P. Aina, B. K. Yao, and P. Drogui, “3D-printed clay-based ceramic water filters for point-of-use water treatment applications,” *Progress in Additive Manufacturing*, vol. *4*, *issue* 3, pp. 315–321, 2019.
[40] B. Bian, D. Shi, X. Cai, M. Hu, Q. Guo, C. Zhang, Q. Wang, A. X. Sun, and J. Yang, “3D printed porous carbon anode for enhanced power generation in microbial fuel cell,” *Nano Energy*, vol. 44, pp. 174–180, 2018.
[41] Y. Ming, Y. Duan, S. Zhang, Y. Zhu, and B. Wang, “Self-heating 3D printed continuous carbon fiber/epoxy mesh and its application in wind turbine deicing,” *Polymer Testing*, vol 82, p. 106309, 2020.

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Establishment of an Academic Makerspace at the Bataan Peninsula State University: Prospects and Challenges

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Abstract. Makerspaces are now fixtures in smart cities and universities in advanced countries. Many universities, especially in the United States, have Academic Makerspaces serving students and faculty, helping them with their projects. At Bataan Peninsula State University, we have recently established an Academic Makerspace called the BPSU MakerLab, as part of our Additive Manufacturing Research Laboratory (AMReL). Our goal is to have an Academic Makerspace with services and facilities at par with international standards. This Academic Makerspace is a place where our students can ideate, conceptualize, build and manufacture their projects, either academic projects, or just extracurricular projects they are interested in. The goal is to promote invention, innovation, creation and making. This study summarizes the best practices of some Academic Makerspaces in the United States and in the Philippines including their facilities. With this study, we have identified what facilities are needed, which equipment to purchase, and what kinds of programs should be made available in an Academic Makerspace. This study specifically provides insights for the short- and long-term programs of BPSU's MakerLab, and could be used to recommend future facilities/services in BPSU. The prospects and challenges of establishing an academic makerspace have also been briefly discussed.

Keywords: Makerspaces, Academic Makerspace, STEM Education, Innovation

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1. Introduction

Makerspaces are increasingly becoming an integral part in academic institutions. Universities, colleges, and even high schools establish these spaces to boost collaboration, creativity, critical thinking and innovation. These spaces promote hands-on and experiential learning to users. Graduates, especially those from the Science, Technology and Engineering courses need to be prepared as they enter the work force. They need to be able to quickly adopt recent technological developments, be more creative, and work with a team. Also, effective communication is very important to be successful at work. [1, 2]. Makerspaces promote creativity and collaboration among users, which essentially serve as a playground or training ground to future engineers and technologists. Makerspaces allow them to harness their creative and critical thinking skills and be relevant and competitive in today's job markets. [1, 3, 4].

Makerspaces provide the necessary tools for students to create their own design ideas, which contribute to the development of their critical thinking skills as well as provide a rich and satisfying learning experience [1]. This is because in makerspaces students are provided with hands-on and collaborative experiences in addressing real-world problems using advanced manufacturing technologies [1, 5]. Makerspaces support the development of technopreneurs [1, 6, 7, 8] and are usually open to the community, and thus promote richer and stronger ties among stakeholders [1, 9, 10]. At Bataan Peninsula State University, we have recently established an Academic Makerspace we call as the BPSU MakerLab, as part of our Additive Manufacturing Research Laboratory (AMReL). The goal of opening an Academic Makerspace inside BPSU's main campus is to provide the necessary facilities to students as well as to improve their design experience. BPSU's academic makerspace hopes to foster collaboration among different disciplines. The study aims to let the researchers understand the important considerations in setting up and operating an academic makerspace, specifically BPSU's MakerLab. This will be done by benchmarking best practices of makerspaces in other parts of the globe and in the Philippines. The prospects and challenges of establishing BPSU's Academic Makerspace is also assessed. BPSU's faculty and students, as well as the local community will benefit from this study. The insights from this study will also benefit other universities/colleges that are planning to set up an academic makerspace.

1.1. Academic Makerspace: Balanga City's Missing Link

The City of Balanga in the Philippines hopes to become the Silicon Valley of the country, i.e. to have thriving and successful technology and startup businesses contributing to the local economy as well as providing employment to its citizens in high tech industries. The city has very aggressive leadership towards the attainment of its goals, however, due to some reasons, the formation of technology businesses in the city remains to be seen. The programs toward the attainment of such vision is presented in Figure 1, together with the support mechanisms provided by educational and government institutions nearby, as well as the efforts being made by the private sector to this end. The city government actually previously supported the operation of a Makerspace which caters to the needs of tech enthusiasts in the city. The figure below shows the representative situation in the City of Balanga in 2017 with regards to establishing an ecosystem for technology startups. One important component missing identified then was the existence of academic makerspaces in the city.

2. Methodology and Materials

The study was divided into four phases namely: (1) Preliminary Meetings / Brainstorming (2) Literature Search (3) Writing/Research and (4) Consolidation of Research Works. In the first phase, the coverage of the whole study was determined, and the tasks and topics were distributed to all members. The goal was to compile the best practices and frameworks of academic makerspaces in the United States and the Philippines. The second phase included readings through many publications and web sources related to Makerspaces and in particular, Academic Makerspaces. Specifically, keyword search using the following keywords: [makerspace], [academic makerspace], etc. have been used. Interviews to administrators of makerspaces, academic makerspaces, and innovation centers in the Philippines were also conducted. Users of makerspaces were not interviewed. No statistical treatment was employed in this study. The third phase included writing of the research paper. Regular meetings were conducted to discuss more ways to enhance the study. Important insights were consolidated and the findings in the study were compared to existing experiences and practices in BPSU.

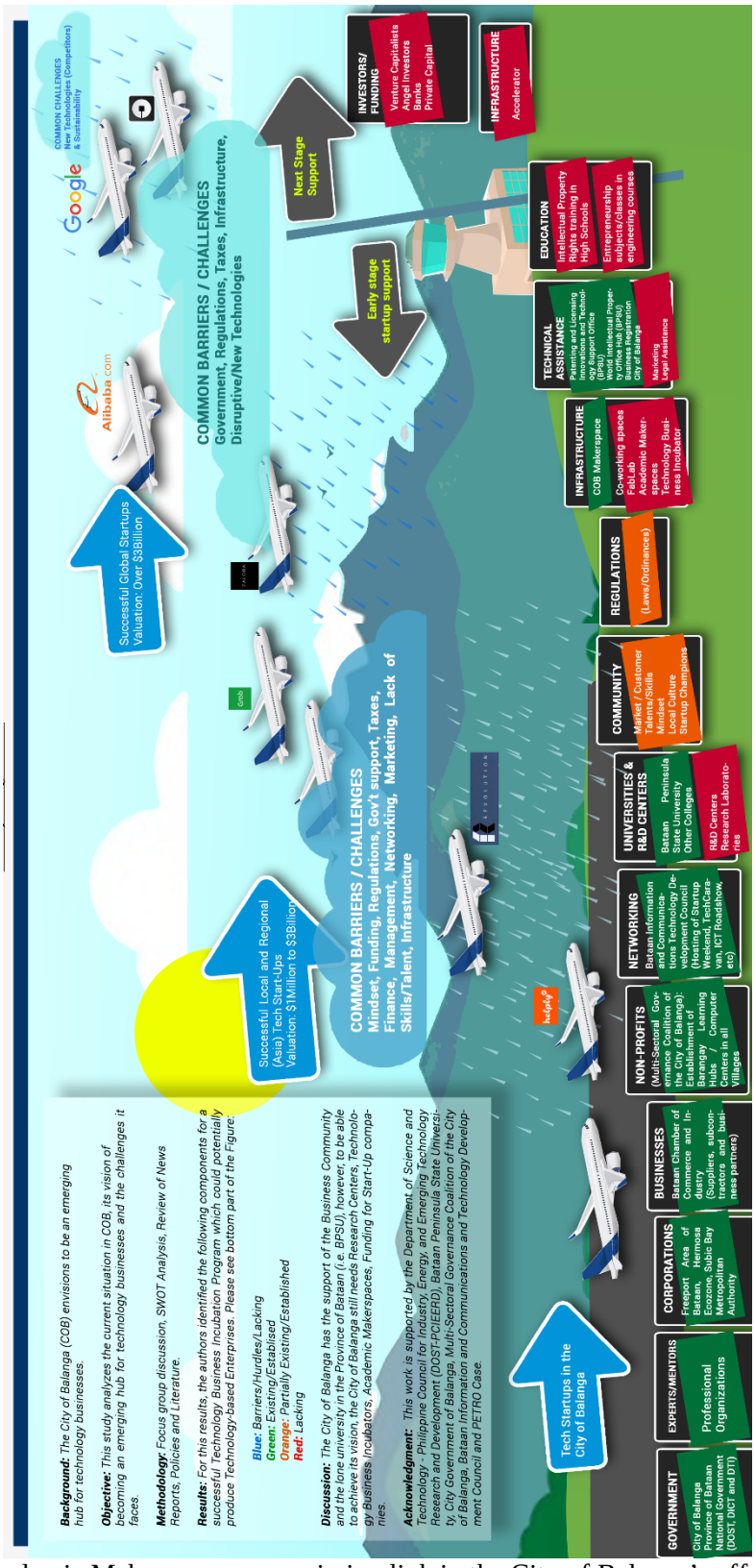

Figure. 1 Academic Makerspaces as a missing link in the City of Balanga's effort for a Tech Start-Up ecosystem

3. Results and Discussion

Wilczynski et al [11] classified the makerspaces based on the scope of the makerspace, accessibility, target users and number of users, management structure and staffing [11]. Further, Galaleldin et al presented several issues in organizing an academic makerspace including the following: Facilities, Programs, Target Clientele and number of users, Financial / Business model, Partners, Accessibility and Operating Hours, and Administrative Structure and Staffing. Also, decisions have to be made such as [1]: Should the makerspace be located within an academic campus? Should the staff belong to an academic institution? What equipment should it have (e.g. laser cutters, 3d printers, CNC machines, etc)? Should it provide training programs / instruction? What should be the guidelines when it comes to using the facility for personal business purposes? Should the academic makerspace generate profits from the operation?

It should be noted that 3d printers, aside from laser cutters, lathe/milling machines, and 3d scanners, are widely used in Makerspaces due to applications in a wide range of applications such as health [12, 13], electronics [14], prototyping and small production runs [15, 16], water filtration and desalination [17, 18], power generation [19], and others [20, 21, 22]. BPSU has also recently established the Philippines' very first Additive Manufacturing Research Laboratory [23], with the MakerLab as an integral part of the facility. It would be good to know how the facilities in BPSU's MakerLab compare with other local and foreign Academic Makerspaces. The insights and ideas generated from this research would contribute in the crafting of operational manuals, as well as in addressing access issues (to make the facility available to faculty, students and the community).

3.1 Best Practices in Academic Makerspaces in the United States

This section presents some overview of the makerspace facilities in the United States and in the Philippines. These examples provide insights on the operation and sustainability of academic makerspaces, and other similar facilities such as fabrication laboratories (fablabs), tech workshops, and others.

3.1.1 Georgia Institute of Technology Invention Studio

The Georgia Institute of Technology Invention Studio is an academic makerspace managed by students. The facility is available to the entire university [24,25]. Their makerspace provides access to equipment as well as training. It also serves as a hub for the maker community within the campus, and supports design instruction (curricular and extra-curricular) to promote collaboration in problem-solving. A student organization manages this makerspace and are assisted by a professional staff and faculty members for logistics support, oversight, and equipment maintenance. The Studio also offers guidance, trainings and workshops as well as outreach activities. The goal is to teach skills and serve as a link for the GA Tech community through design and problem-solving collaboration. [24,25].

3.1.2 Yale Center for Engineering Innovation and Design

The Yale Center for Engineering Innovation and Design (CEID) is a makerspace open to all university faculty, students and staff [24, 25]. The facility offers training sessions, workshops, and design classes that help users translate ideas into functional devices. With lecture space, meeting rooms, machine shops, an open studio, and a wet lab, the facility promotes design-based collaborations among its users to support faculty and student projects and activities (curricular, co-curricular, and extra-curricular). The center has also played an important role promoting engineering as an academic consideration for other disciplines. A director and 2 design faculty members and 2 design fellows, student assistants, provide guidance, teach skills, and oversee operations in the makerspace. [24, 25]

3.1.3 Case Western Reserve University Sears think[box]

Case Western Reserve University's Sears think[box] supports making and building, promotes innovative thinking, facilitates multidisciplinary collaboration, and advances product development and venture creation. The facility is open to all faculty and students as well as the local community (~20% of visitors). The facility combines collaboration programming, makerspace equipment, startup guidance, and incubation facility in one building and under one organizational structure. The 7 floors of the facility

were designed to support rapid prototyping, advanced manufacturing, assembling, meeting and brainstorming, collaborating, commercialization and entrepreneurship with one floor dedicated to each step of the process. There is an intellectual property section, an incubator and accelerator. Think[box] is managed by a faculty director and an executive director [24, 25]

3.2. Best Practices of Makerspaces in the Philippines

3.2.1 Saint Louis University TechHub

The Saint Louis University (SLU) in Baguio City recently established its Technopreneurship Hub (SLU TechHub). The TechHub is a joint project of the Department of Science and Technology (DOST), the Department of Trade and Industry (DTI), and the Commission on Higher Education (CHED). The TechHub provides an ecosystem starting from immersion and creativity to innovation and technology, and then towards knowledge creation and intellectual property, and eventually commercialization. SLU is among the first five tech hubs in the Philippines offering design consultancy, prototyping, fabrication, trainings and workshops, mentoring, co-working space, networking and business planning. [26, 27]. Table 1 summarizes the facilities inside SLU's Tech Hub [26, 27].

Table 1. Facilities at SLU's Tech Hub

SLU Incubator for Research, Innovation, and Business (SIRIB Center) ***SIRIB is an Ilocano word which means "intellect".**	This facility aims to support research and development initiatives. This is where students are taught and guided through ideation and design thinking.
Fabrication Laboratory (FabLab) ***This is a DTI Shared Service Facility**	This facility is where MSMEs together with SLU faculty and students collaborate and realize their designs.
SLU-DOST Convergent Resilience Technology Business Incubator (ConRes TBI)	This facility provides technology incubation, and potentially become business ventures - commercialized. Business support, coaching, mentoring and Intellectual Property Rights advising is provided in this facility.

3.2.2 Miriam College

THE SM group has donated an innovation center (makerspace) to Miriam College. The innovation hub is located near the entrance of Miriam College campus in Quezon City. The facility was envisioned to immerse its students and faculty in a new model of teaching and learning focusing on the following: design, robotics, engineering, entrepreneurship, arts and mathematics (DREAM). It is expected that this facility will help bring improvement to current instruction practices in the institution [28]. It has a fabrication laboratory (fablab) among other facilities, which serves as a digital manufacturing hub to its students. Table 2 summarizes the facilities inside their innovation center [28].

Table 2. Summary of Facilities at Miriam College's Innovation Hub

Fabrication Laboratory (FAB LAB)	**This is a creative workshop which has several computer-controlled equipment and tools. In this facility, students can turn their ideas into prototypes as they have access to advanced digital manufacturing technology.**
Electronics Laboratory (E-LAB)	This facility has the latest programming resources and building materials to learn coding and robotics. This is a venue for collaboration providing a fun atmosphere to create systems to improve lives.
Multi-Media Laboratory (MULTI-MEDIA LAB)	This facility enables students to work collaboratively using web authoring equipment and software. Tools for animation, software development web design, graphic design, video manipulation and digital audio are provided here.
Instrumentation	This facility has several hand-held tools, building materials and sensors. This

Laboratory (INSTRU LAB)	is an ideal space for STEM (science, technology, engineering, and mathematics) students.
PERFORMANCE LABORATORY	This 21st-century model classroom features interactive projectors which could be used in remote learning, developing digital art skills, and collaborative learning. This facility can be converted into a free space for group meetings, and also into a conference room and art exhibition room.
MAKERS' CAFÉ	This is a dining facility as well as a food business simulation and incubation area. Students and teachers may use this facility to explore new trends in the food industry.
INNOVATRIUM	This facility is basically a theater, where people can perform. It can also be a pitching area where students can discuss their ideas and innovative concepts.

Academic Makerspace at the Bataan Peninsula State University

The available equipment at BPSU's MakerLab are as follows: Stereolithography 3d Printer, Fused Deposition 3d Printers, UV Curing Apparatus, Injection Molding Machine, Filament Extruder, Filament Winder, Ultrasonicator, Microscope, and 3d Scanner. The MakerLab has already catered to numerous faculty and student research projects, and is a major facility being utilized by the various research units and projects related with 3d printing (Additive Manufacturing). To be a world-class facility and be at par with other Academic Makerspaces in this study, BPSU needs to provide more facilities/equipment similar to the other Academic Makerspaces mentioned in this paper. BPSU MakerLab has been jointly established by BPSU and DOST's Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD). BPSU may also consider tapping other fund sources such as the Department of Trade and Industry (DTI), Commission on Higher Education (CHED), and other divisions of the Department of Science and Technology (DOST). Access policies (including pricing of services) to the MakerLab may be provided by the authors upon request.

4. Prospects of establishing an academic makerspace

The following are some compelling reasons why Academic Makerspaces are needed in academic institutions.

1) Access.

- There are many students needing facilities that an Academic Makerspace can offer which includes ideation, prototyping, mentoring, collaboration [29].

2) Research Facility.

- An Academic Makerspace will be a valuable facility for faculty and student researchers. Collaborative research projects may be explored in academic makerspaces where faculty and student projects can be conducted [30]

3) Promotion of 21st Century Learning Skills.

- An Academic Makerspace promotes the 21st Century Learning Skills (namely, critical thinking, collaboration, communication and creativity), and thus would be a vital component for an academic institution for its creative/design programs and activities. [31, 32].

4) Industry Linkages.

- The industry could benefit from the prototyping facilities provided by innovation laboratories such as an Academic Makerspace. An Academic makerspace could be a venue where the industry can bring up problems in design and packaging, and where faculty and students can help solve these problems. [6]

5. Challenges of establishing an academic makerspace

1) Funding.

- The cost of the needed equipment and materials could be prohibitive. High Tech equipment which includes 3d printers, laser cutters, milling/turning machines, etc. could be quite expensive. This will depend on the size, quality of output, brand name, and other factors.

2) Limited Access.
- Access could be an issue, as the facility is primarily available for use of BPSU faculty and students. Also, the operating hours is limited to the operating hours of offices (i.e. usually only open on weekdays, 8-5pm).
3) Monitoring.
- Monitoring the use of equipment, tools and materials could be a challenge, given the diverse nature of equipment and materials found in the makerspace.

4) Operation.
- Managing the day-to-day operation of the academic makerspace could be a challenge as a full-time staff is needed in order to properly manage all the activities in the makerspace (e.g. training, repair, use of equipment/tools, inventory of materials and supplies, etc).

6. Summary and Conclusion

This study summarizes the best practices of some Academic Makerspaces in the United States and in the Philippines. With this study, the facilities and equipment needed, and the kinds of programs that should be made available in an Academic Makerspace have been identified. Fund source, possible partner agencies, and other important details have been discussed in passing. This study provides insights for the short- and long-term programs of BPSU's Academic Makerspace, and could be used to recommend future facilities/services in BPSU. Lastly, the prospects and challenges of establishing an academic makerspace have also been briefly discussed.

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References:

[1] M. Galaleldin, F. Bouchard, H. Anis, and C. Lague, "The Impact of Makerspaces on Engineering Education," Proceedings of the Canadian Engineering Education Association (CEEA), DOI: 10.24908/pceea.v0i0.6481, 2017.

[2] T. Byers, T. Seelig, S. Sheppard and P. Weilerstein, "Entrepreneurship: Its Role in Engineering Education," Bridg. - Natl. Acad. Eng., vol. 43, no. 2, 2013.

[3] V. Wilczynski, "Academic maker spaces and engineering design," Proceedings of the ASEE Annual Conference and Exposition, vol. 122nd ASEE, no. 122nd ASEE Annual Conference and Exposition: Making Value for Society, DOI:10.18260/p.23477, 2015.

[4] J. L. Saorín∗, D.Melian-Díaz, A. Bonnet, C. C. Carrera, C. Meier, J. De La Torre-Cantero, "Makerspace teaching-learning environment to enhancecreative competence in engineering students", Presentation at the 2017 International Symposium of Academic Makerspaces (ISAM 2017), Case Western Reserve University, Cleveland, Ohio, Sept. 24-27, 2019.

[5] C. R. Forest, R. A. Moore, A. S. Jariwala, B. B. Fasse, J. Linsey, W. Newstetter, P. Ngo, and C. Quintero, "The invention studio: A university maker space and culture," Adv. Eng. Educ., vol. 4, no. 2, 2014.

[6] E. J. Van Holm, "Makerspaces and Contributions to Entrepreneurship," Procedia - Soc. Behav. Sci., vol. 195, pp. 24–31, 2015.

[7] V. Wilczynski, A. McLaughlin, Similarities and Differences between Academic Centers for Entrepreneurship, Innovation, and Making, Presentation at the 2017 International Symposium of Academic Makerspaces (ISAM 2017), Case Western Reserve University, Cleveland, Ohio, Sept. 24-27, 2019.

[8] J. Michael Poole, “Prototyping Spaces for Entrepreneurship”, Presentation at the 2017 International Symposium of Academic Makerspaces (ISAM 2017), Case Western Reserve University, Cleveland, Ohio, Sept. 24-27, 2019.
[9] J. Moilanen, “Emerging Hackerspaces – Peer-production Generation,” pp. 94–111, 2012.
[10] U. Shehzad, A. Murtaza, and M. Naseem, “Role of Academic Makerspaces in Creating Social Impact, Presentation”, at the 2017 International Symposium of Academic Makerspaces (ISAM 2017), Case Western Reserve University, Cleveland, Ohio, Sept. 24-27, 2019.
[11] V. Wilczynski, A. Hoover, “Classifying Academic Makerspaces”, Presentation at the 2017 International Symposium of Academic Makerspaces (ISAM 2017), Case Western Reserve University, Cleveland, Ohio, Sept. 24-27, 2017.
[12] R. C. Advincula, J. R. C. Dizon, Q. Chen, I. Niu, J. Chung, L. Kilpatrick, and R. Newman, “Additive manufacturing for COVID-19: devices, materials, prospects, and challenges,” MRS Commun., vol. 10, no. 3, pp. 413–427, 2020.
[13] J. R. R. Diego, D. W. C. Martinez, G. S. Robles, and J. R. C. Dizon, “Development of Smartphone-Controlled Hand and Arm Exoskeleton for Persons with Disability,” Open Eng., vol. 11, pp. 161–170, 21AD.
[14] A. H. Espera, J. R. C. Dizon, Q. Chen, and R. C. Advincula, “3D-printing and advanced manufacturing for electronics,” Prog. Addit. Manuf., vol. 0, no. 0, p. 0, 2019, doi: 10.1007/s40964-019-00077-7.
[15] J. R. C. Dizon, A. D. Valino, L. R. Souza, A. H. Espera, Q. Chen, and R. C. Advincula, “3D Printed Injection Molds using various 3D Printing Technologies,” Mater. Sci. Forum, vol. 1005, pp. 150–156, 2020, doi: https://doi.org/10.4028/www.scientific.net/MSF.1005.150.
[16] J.R.C. Dizon, A.D. Valino, L.R. Souza, A.H. Espera, Jr., Q.Chen, R.C. Advincula, Three-dimensional-printed molds and materials for injection molding and rapid tooling applications, 2019, MRS Communications Prospectives Journal, 9, 4, DOI: https://doi.org/10.1557/mrc.2019.147.
[17] L. D. Tijing, J. R. C. Dizon, I. Ibrahim, A. R. N. Nisay, H. K. Shon, and R. C. Advincula, “3D printing for membrane separation, desalination and water treatment,” Appl. Mater. Today, vol. 18, 2020, doi: 10.1016/j.apmt.2019.100486.
[18] L.D. Tijing, J. R. C. Dizon, and G.G. Cruz, “3D-Printed Absorbers for Solar-Driven Interfacial Water Evaporation: A Mini-Review,” Advance Sustainable Science, Engineering, and Technology, vol. 3, no. 1, 2021.
[19] N. Andres, "Development of Solar-Powered Water Pump with 3D Printed Impeller" Open Engineering, vol. 11, no. 1, 2021, pp. 249-253. https://doi.org/10.1515/eng-2021-0015
[20] J. R. C. Dizon, A. H. Espera, Q. Chen, and R. C. Advincula, “Mechanical characterization of 3D-printed polymers,” Addit. Manuf., vol. 20, 2018, doi: 10.1016/j.addma.2017.12.002.
[21] J. R. C. Dizon, C. C. L. Gache, H. M. S. Cascolan, L. T. Cancino, R. C. Advincula, Post-processing of 3D-printed Polymers, Technologies, 2021, 9(3):61. https://doi.org/10.3390/technologies9030061.
[22] A. D. Valino, J. R. C. Dizon, A. H. Espera Jr., Q. Chen, J. Messman, R. C. Advincula, Advances in 3D Printing of Thermoplastic Polymer Composites and Nanocomposites, Progress in Polymer Science, Volume 98 https://doi.org/10.1016/j.progpolymsci.2019.101162.
[23]https://www.metal-am.com/two-additive-manufacturing-research-facilities-to-open-in-the-philippines/
[24] V. Wilczynski, A. McLaughlin, “Similarities and Differences between Academic Centers for Entrepreneurship, Innovation, and Making”, Presentation at the 2017 International Symposium of Academic Makerspaces (ISAM 2017), Case Western Reserve University, Cleveland, Ohio, Sept. 24-27, 2019.
[25] P. J. Ali, M. Cooke, M. L. Culpepper, C. R. Forest, B. Hart-mann, M. Kohn., and V. Wilczynski,“The Value of Campus Collaboration for Higher Education Makerspaces”, International Symposium on Academic Makerspaces 2016, Cambridge, Massachusetts, 2016.
[26] https://www.pna.gov.ph/articles/1076713

[27] https://www.mc.edu.ph/innovation-center
[28] https://business.inquirer.net/214634/henry-sy-donates-p100m-innovation-hub-to-miriam-college
[29] N. Gerschenfeld, “How to Make almost Anything - the Digital Fabrication Revolution”, Foreign Affairs, vol. 91, no. 6, pp. 43-57, 2012.
[30] P. Blikstein, “Digital fabrication and ‘making’ in education: The democratization of invention”, in: J. Walter-Herrmann, C. Büching (Eds.), FabLabs: Of Machines, Makers and Inventors, Bielefeld, DOI:10.14361/TRANSCRIPT.9783839423820.203, 2013.
[31] R. Smith, O. S. Iversen, M. Hjorth, “Design thinking for digital fabrication in education”, Int. J. Child-Comput. Interact. vol. 5, pp. 20-28, 2015.
[32] J. C. K. Tham, “Writing in the Making: Integrating Design Thinking, Collaboration, and Material Literacy with Technical Writing Pedagogy”, Proceedings of ISAM 2017, Paper No.: 048, 2017.

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Correlation of Sex Ratio and Population of *Callosobruchus chinensis* L. (Coleoptera: Bruchidae) in Mung Beans

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Abstract. One of the important pests on mung beans is the warehouse pest *Callosobruchus chinensis* (Coleoptera: Bruchidae). These pests can cause yield losses of up to 90%. Populations of adult *C. chinensis* have a close correlation in influencing the development of this pest in mung bean storage. This study aims to determine the correlation between the sex ratio of the population and its development in *C. chinensis* and to see its preference for mung beans. This research was conducted at the Plant Breeding Laboratory, Brawijaya University. The method was carried out by investing adult *C. chinensis* in mung beans based on the sex ratio, there are four sex ratio comparisons observed. Observations were made every week to see the number of eggs, larvaes, adults and dead insects. Based on the results of the study, the sex ratio of 2 males and 3 females resulted in the highest number of populations, a total of 72 eggs and 46 adult *C. chinensis.* Our hypothesis is that a high sex ratio leads to an increase in the population of *C. chinensis.* The vima variety is resistant mung beans compared to consumption varieties because it has lower seed weight loss. The results of this study are preliminary results that can be used for further research to evaluate the correlation between sex ratio, population and development of *C. chinensis.*

Keywords: *Callosobruchus chinensis*, mung beans, sex ratio, warehouse pest

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1. Introduction

Storage of post-harvest results is the final stage of the plant cultivation system which has the main problem of attack by warehouse pests. Warehouse pests are one of the main problems in the seed storage process. Various types of agricultural products are attacked by warehouse pests, which are mung beans (*Vigna radiata*). The quality of mung bean seeds must be considered to make a healthy plant. One of

the things that underlie the quality of mung bean seeds is seed resistance. Each seed has a different resistance depending on the variety and cultivation environment. Seed resistance can be seen from resistance to diseases and pests. Decreases in agricultural commodity yields can occur before harvest, after harvest and during storage. An important warehouse pest that attacks mung beans is *Callosobruchus chinensis* (Coleoptera: Bruchidae). Yield losses due to *C. chinensis* on mung beans can reach 90% [1], even up to 96% so that mung beans cannot be used for consumption or seeds in agricultural cultivation [2]. This pest is one of the most serious pests of stored beans, which has been widely distributed in many countries and carried over to bean exports [3].

The host preference of *C. chinensis* depends on several factors. Pest preferences include pest habits, pest response to color and light intensity, physical structure and plant surface, the presence of chemical compounds produced by the host, and plant morphological structures such as hairs on the tissue surface and hard and thick leaf skin [4], [5]. Nutritional stress during their developmental life made the size of the imago *C. chinensis* smaller. This may result in smaller eggs because egg size is positively correlated with body size in various insect taxa [6], [3]. The newly hatched larvae of *C. chinensis* feed on the seeds, causing loss of nutrition and seed germination [7], [8].

The behavior of *C. chinensis* based on population in stored beans has not been widely carried out. Adult have habits in their life, like host selection, finding a mate, egg placement, and self-defense [9]. The difference between the two sexes of *C. chinensis* is that males have larger and more intricately shaped antennae, while females have serrated antennae [10]. *C. chinensis* females produce larger eggs when there is a competitor, than without competition [3]. The purpose of this study was to determine the correlation between sex ratio and the population of *C. chinensis* in mung beans, and also to determine their preferences for two different varieties, vima and consumption.

2. Methods

This research was conducted at the Plant Breeding Laboratory, Faculty of Agriculture, Brawijaya University. The tools needed are analytical scales, vials, bottles, gauze, Petri dishes and tweezers. While the materials needed are mung bean seeds, vima and consumption varieties, and adult of *C. chinensis.*

2.1 Population correlation with development of C. chinensis

Adult of *C. chinensis*. invested in a film fial containing 15 gr of mung beans. Then the film is covered with gauze. Observe the population *C. chinensis* every week. The treatments include (a): *C. chinensis* with the composition of 1 male 1 female, (b): *C. chinensis* with the composition of 1 male 2 females, (c): *C. chinensis* with the composition of 1 male 3 females, (d): *C. chinensis* with the composition of 2 males 3 females.

2.2 C. chinensis preference Based oOn Two Mung Bean Varieties

Prepared materials for storage by weighing each mung beans weighing 100 grams, for each type. Prepared two glass bottles for the two types of mung beans. Put each storage material into a bottle by adding 10 adult *C. chinensis* in each treatment. Cover the bottle with gauze to ensure that *C. chinensis* remains alive. Observations were made every week by counting the number of *C. chinensis* and measuring the weight of mung beans.

3. Results and Discussion

Based on observations, there was a change in the population of *C. chinensis* invested in mung beans in all treatments. The occurrence of population changes occurred in addition to eggs, new adult and the number of adult deaths. The composition of several sex ratios is determined by the ratio of different males and females, observations were made on adults C. *chinensis* until maturity occurs, which is observed at one to four weeks. In this observation no larvae and pupae were found, only the addition of eggs and adults of *C. chinensis.*

The results of the sex ratio of *C. chinensis* from Table 1, sex ratio with a composition of 1 male 1 female, all adult *C. chinensis* died in the second week and no additional eggs occurred. While in the

composition of 1 male 2 female, new eggs and adult appeared. In the first to third week observations, the number of eggs was 42 eggs and adult became 30, however 8 adults died. The population also increased in the *C. chinensis* with a composition of 1 male 3 female, new eggs and adults were found. In the first to third week of 42 eggs, the adult increased to 35, and there were 9 adults died.

Table 1. *C. chinensis* with several sex ratio composition

Composition of the sex of *C. chinensis*	**Observation**	**∑ Eggs**	**∑ Larvae**	**∑ Pupae**	**∑ Adults**	**∑ Death adults**
1 male 1 female	1	-	-	-	-	-
	2	-	-	-	-	2
1 male 2 females	1	14	-	-	23	1
	2	38	-	-	30	2
	3	42	-	-	30	5
1 male 3 females	1	38	-	-	30	3
	2	38	-	-	35	2
	3	42	-	-	35	4
2 males 3 females	1	42	-	-	19	2
	2	50	-	-	28	2
	3	64	-	-	46	1
	4	72	-	-	46	2

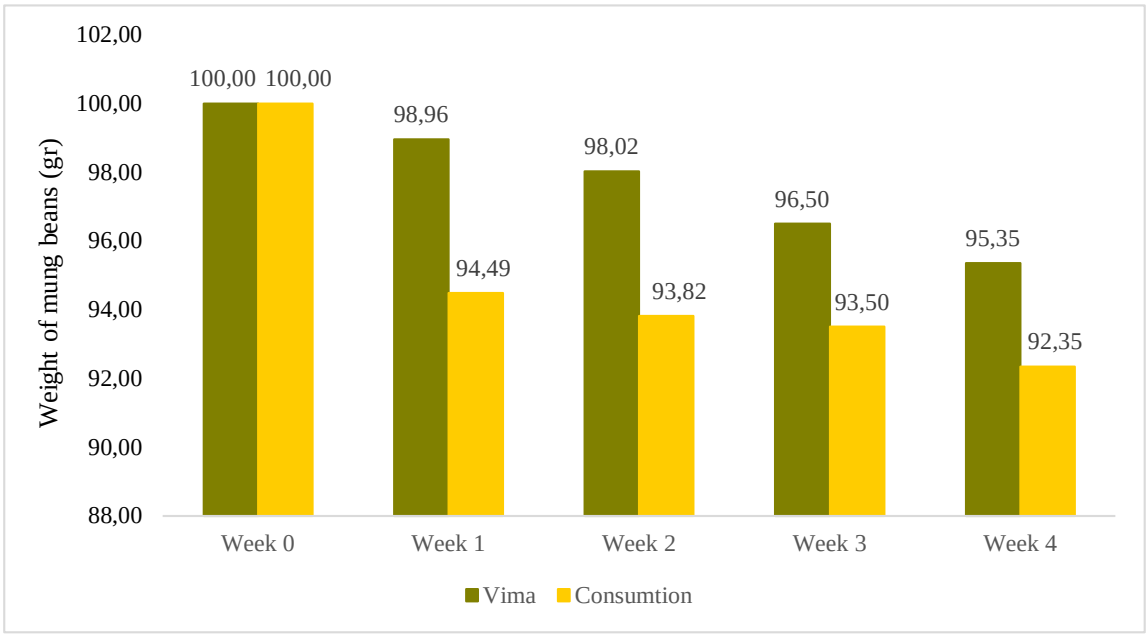

Figure 1. Weight of mung beans invested with *C. chinensis*

Based on all the data, the results showed that the composition of the comparison of *C. chinensis* 2 males and 3 females at the final observation had a larger population of 72 eggs and 46 adults. This result occurred because the comparison of the number of *C. chinensis* adult invested affected the *C. chinensis* population from the number of eggs and new adult. The greater number of males and females will affect the potential for increased egg laying and population growth. This is supported by [11] sex ratio affects the number of insects that exist so that the population is increasing. The results of the number of eggs

produced by *C. chinensis* in this study were in accordance with studies which stated that the egg laying of *C. chinensis* produced 78 eggs on average [12].

Population development of *C. chinensis* is caused by several factors. The presence of internal and external factors influenced the development of *C. chinensis* populations, such as seasonality and population density, which means that the sex ratio may change the development of insects [13]. Environmental influences such as temperature and humidity also affect the laying condition of *C. chinensis*. According to [14] The female lays eggs on the surface of the host seed about 4-5 days later at a temperature of 26-28^{o}C, then has a life cycle of between 21-31 days [5]. The eggs found in this study were oval and transparent. This is in accordance with [5] which states that *C. chinensis* has oval, transparent and yellow eggs. The incubation period for eggs is between 4-5 days. The larvae are clear yellow with a brown head and undergo skin changes to become pupae. Adults initially yellowish white on the head will form brown spots which gradually turn black. This collection of spots will become compound eyes. Then the whole body starting from the head gradually turned brown.

In the study of *C. chinensis* preferences for mung beans. At 4 weeks of observation, the weight of all mung bean seed varieties decreased (Fig. 1). The largest number of declines occurred in consumption varieties than vima varieties. This can be seen from the difference in initial weight and final weight where the decrease is smaller than the consumption variety. The difference in seed weight at the beginning of the observation until the 4th week for consumption mung beans reached 7.65 and 4.65 g for vima variety. The greater the difference in the weight of mung bean, the more susceptible it is to *C. chinensis.* This is in accordance with the statement [15] and supported by [16] which said that the value of the difference in weight of 100 seeds before and after insect investment was getting bigger, it was stated that the variety was susceptible to *C. chinensis* attack. The decrease in seed weight in all varieties was not only caused by *C. chinensis,* it may also be the presence of moisture stored in the seeds. The higher the water content, the greater the weight of 10 grams of seed [15]. This study also revealed that the type of seed affects the development of the pest population. If the seeds are susceptible and not resistant to *C. chinensis*, the seeds can be used as hosts for these pests and reduce the quality of mung bean seeds. According to [17] mung bean seeds that have been attacked by insect pests have an unpleasant or distinctive smell which is the result of secretions from insects.

4. Conclusion

The results showed that *C. chinensis* which consisted of 2 males and 3 females in mung beans at the final observation had a larger population of 72 eggs and 46 adults. Vima has a fairly good resistance to *C. chinensis* compared to the consumption mung beans. This research is a preliminary study, it needs more observations and stages of research to explain further about the sex ratio of *C. chinensis* and its population in mung beans.

Acknowledgements

Thanks to the Faculty of Agriculture Brawijaya University for facilitating this research. We cannot thank you enough to dear Miss Nanda Ulfa Rizki, a practicum assistant of seed production technology who has helped us, may her soul rest in peace, we will never forget what she has done. We would also like to thank Agroecotechnology 2014 colleagues who have helped us during the research.

References

[1] A. Muhammad, F. A. Shaheen, and A. Ayyaz, "Management of *Callosobruchus chinensis* Linnaeus in Stored Chickpea Through Interspecific and Intraspecific Predation by Ants," *World J. Agric. Sci.*, vol. 2, no. 1, pp. 85–89, 2006.

[2] A. G. Kartasapoetra, "Hama Tanaman Pangan dan Perkebunan," Bumi Aksara, Jakarta, 1990. (Indonesian)

[3] S. I. Yanagi, Y. Saeki, and M. Tuda, "Adaptive egg size plasticity for larval competition and its limits in the seed beetle *Callosobruchus chinensis*," *Entomol. Exp. Appl.*, vol. 148, no. 2, pp. 182–187, 2013.

[4] G. L. Teetes, “Plant Resistance to Insects: A Fundamental Component of IPM,” Texas, 1996.
[5] M. Musalamah, “Peningkatan Ketahanan Kacang Hijau Terhadap Hama Gudang *Callosobruchus chinensis*: Dari Pendekatan Konvensional Menuju Bioteknologi,” *Bul. Palawija*, no. 9, pp. 33–42, 2005.
[6] C. W. Fox and M. E. Czesak, “Evolutionary ecology of progeny size in arthropods,” *Annu. Rev. Entomol.*, vol. 45, pp. 341–369, 2000.
[7] S. M. Mandal, D. Chakraborty, S. Dey, S. M. Mandal, D. Chakraborty, and S. Dey, “Phenolic acids act as signaling molecules in plant- microbe symbioses Phenolic acids act as signaling molecules in plant-microbe symbioses,” *Plant Signal. Behav.*, vol. 5, no. 4, pp. 359–368, 2017.
[8] S. K. Khinchi, M. M. Sharma, M. K. Khinchi, R. P. Naga, and D. Acharya, “Studies on efficacy of certain plant part powders against pulse beetle , *Callosobruchus chinensis* Linn . on chickpea, *Cicer arietinum* (L),” vol. 5, no. 3, pp. 575–578, 2017.
[9] O. D. Amusa, L. A. Ogunkanmi, J. A. Adetumbi, S. T. Akinyosoye, and O. T. Ogundipe, “Genetics of bruchid (*Callosobruchus maculatus* Fab.) resistance in cowpea (*Vigna unguiculata* (L.) Walp .),” *J. Stored Prod. Res.*, vol. 75, pp. 18–20, 2018.
[10] A. Colgoni and S. M. Vamosi, “Sexual dimorphism and allometry in two seed beetles (Coleoptera: Bruchidae),” *Entomol. Sci.*, vol. 9, no. 2, pp. 171–179, 2006.
[11] N. S. Talekar, “Biologi, Damage and Control of Bruchid Pest of Mungbean,” in *Proceeding of the Second International Symposium*, 1988, pp. 329–242.
[12] Talekar and Y. H. Lin, “Two source with differing modes of resistance to *Callosobruchus chinensis* (L.) in mungbean.,” *J. Econ. Entomol*, vol. 74, no. 5, pp. 639–642, 1985.
[13] Jumar, *Entomologi pertanian*. Jakarta: Rineka Cipta, 2000.
[14] C. W. Fox and M. Tatar, “Oviposition substrate affects adult mortality, independent of reproduction, in the seed beetle *Callosobruchus maculatus*,” *Ecol. Entomol.*, vol. 19, pp. 108–110, 1994.
[15] A. Supeno, “Identifikasi ketahanan varietas kacang hijau terhadap infestasi hama gudang *Callosobruchus chinensis* (L.),” *Bul. Pertan.*, vol. 10, no. 2, pp. 65–68, 2005. (Indonesian).
[16] P. Somta, C. Ammaranan, P. A.-C. Ooi, and P. Srinives, “Inheritance of seed resistance to bruchids in cultivated mungbean (*Vigna radiata*, L . Wilczek),” *Euphytica*, vol. 155, pp. 47–55, 2007.
[17] Kardiyono, “Efektivitas Abu Sekam dan Minyak Goreng pada Pengendalian Hama Gudang Kacang Hijau,” Banten, 2008. (Indonesian).

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Utilization of E-money for School Payments Using Web-Based RFID Sensors

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Abstract. School payments are a very important issue to support a school that is used to meet infrastructure and other needs. Therefore, if there is an error in writing or the loss of payment data, a difficult problem will arise. Because the payment process is still manual using a notebook.By utilizing E-money and RFID Sensors in the school payment process, it will be very helpful to create an effective and efficient payment process. In this work we develop an application that uses a school student card as a personal identity in searching for data that will be linked to a web as a basis. In paying school fees, you can also use E-money for the payment process. Therefore, the author will use electronic money to process the payment. That is by utilizing server-based electronic money in the form of applications such as OVO and DANA. Because it is easier and has been registered with Bank Indonesia, it will be guaranteed safe. The way it works is the first by installing an RFID sensor on the student card which functions as a means of finding personal data or identity so there is no need to search for data one by one manually. Then it will be connected to the website as a payment basis, which when the RFID sensor is successful in scanning student data, a payment option will appear, which can pay directly or via OVO and DANA electronic money which is already available in the application we made. This will make it easier for students to process school payments

Keywords:E-money, RFID Sensor, School Payment, Web

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1. Introduction

Technological development is a series of activities that are carried out continuously and aim to achieve a state or condition that is better than before[1]. At this time world civilization has shown technological developments, along with these technological advances, humans are required to work more effectively and efficiently in order to obtain faster, precise and accurate results[2]. One technology that is currently developing is E-money[3]. According to Wikipedia E-money or electronic money (digital money) is money used in internet transactions by electronic means. E-money is also often referred to as Electronic Cash, Digital Money, Digital Cash, Electronic Currency and Digital Currency. E-money can be safe to

use because electronic money is very difficult to hijack or hack. So there is no worry when using this money[4]. Some examples of E-money applications are OVO, Dana, Gopay, Link Aja, Brizzi BRI.

RFID sensors are used because they are more durable and not easily damaged, considering that students are still junior high school students who are sometimes careless and less careful. Because if you use other sensors such as barcodes, it will be a problem if the barcode is damaged, the student card will no longer be able to be used to make school payments. While the RFID sensor will be more durable because the sensor is located inside the card so that if the card is scratched or damaged on the outside, the RFID sensor will still function[5].

By utilizing school student cards as self-identity in finding data that will be linked to the web as a basis. In paying tuition, you can also use E-money for the payment process. In this work, we develop an application that uses electronic money to process payments. By utilizing server-based electronic money in the form of applications such as OVO and DANA. Because it is easier and has been registered with Bank Indonesia, it is guaranteed to be safe [6]. The first way it works is by installing an RFID sensor on the student card which functions as a means of searching for personal data or self-identity so that there is no need to search for data one by one manually. Furthermore, it will be linked to the website as a basis for payment, where when the RFID sensor is successful in scanning student data, a payment option will appear which can be paid directly or through the available OVO and DANA electronic money.

2. Methods

a) Understanding E-Money

The meaning of e-money refers to a definition issued by the Bank for International Settlement (BIS) in one of its publications in October 1961. In that publication e-money is defined as “a viable or prepaid product stored in which records of funds or available to consumers stored on a consumer's electronic device” (stored or prepaid product where the monetary value is stored in a person's electronic media). It is further explained that the value of money in e-money will decrease when consumers use it for payments. The electronic money discussed here is different from other “single prepaid cards” such as telephone cards, because the electronic money referred to here can be used for various types of payments (multipurpose). E-money referred to here is also different from other card-based electronic payment instruments such as credit cards and debit cards. Credit and debit cards are “prepaid products” but are “access products”[7].

b) School Payment

“SPP (Education Support Contribution) is a monthly fee or payment from students which is an obligation for students at school. The tuition fee is taken based on the agreement of the school committee meeting and the parents of the students. Tuition fees are shown to support improving the quality of education related to teaching and learning activities facilities and infrastructure”

c) RFID Sensor

RFID (Radio Frequency Identification) technology is a technology used for identification and verification using radio waves that do not require direct contact between the object and the reader[8]**.** RFID is a technology that can identify several objects at once without direct physical contact. RFID technology requires three main components, namely the RFID Tag which is in the form of a thin and small chip, the RFID Reader which is used to read the data on the Tag, and an application that processes the data obtained through the Reader. The components contained in RFID are RFID Tag and RFID Reader. Based on the RFID Tag, RFID is divided into two. (a) Active This tag uses battery power and has a longer reading distance, from 20 meters to 300 meters. This tag does not reflect the radio signal, but instead sends the radio signal. (b) Passive Passive Tag is a conventional tag that reflects the signal given by the reader. Passive tag reading distance is relatively short. This tag has a shape like a chip sheet so it is easy to apply in various media. Passive tags can operate at low, high, and ultrahigh frequencies. On the other hand, RFID Reader is used to send and receive signals from tags. RFID Reader can read

tags roughly (RAW) and has no computational capabilities. Middleware Middleware is an application that receives data from the reader and processes it to suit system requirements. Middleware can do any work such as filtering RAW data and monitoring the state of the reader.

d) WEB

The website is: "The web can be interpreted as a collection of pages that display text data information, image data, animation data, sound, video and a combination of all of them, both static and dynamic which form a series of buildings that interconnected, each of which is linked by hyperlinks[9]. The web is: "A collection of pages consisting of several pages that contain information in the form of digital data in the form of text, images, video, audio, and other animations provided through an internet connection"[10].

e) ERD

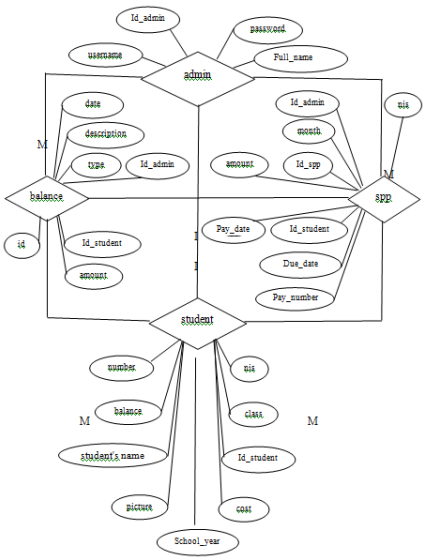

Figure 1. Entity Relationship Diagram

Figure 1. is an entity relationship diagram. The entity relationship diagram describes how a field and a table are related. There are several tables in the database.

3. Results and Discussion

Program Implementation

a. Login View

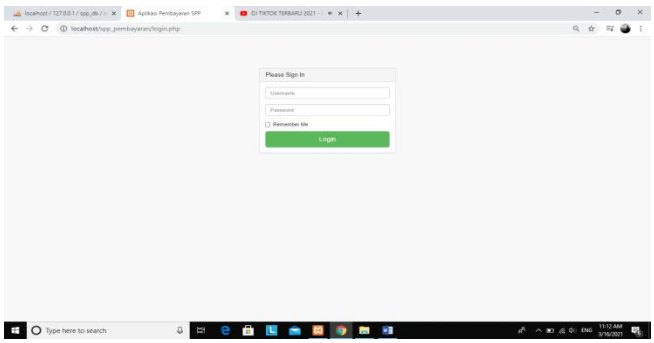

Figure 2. Login View

Figure 2. describe login view. Login or sign in is a term in terms of computer security, namely in the form of an entrance process for users to access computer systems. Login is intended to manage the identification process. Therefore admins are required to login first in order to start school payment transactions.

b. Dashboard View

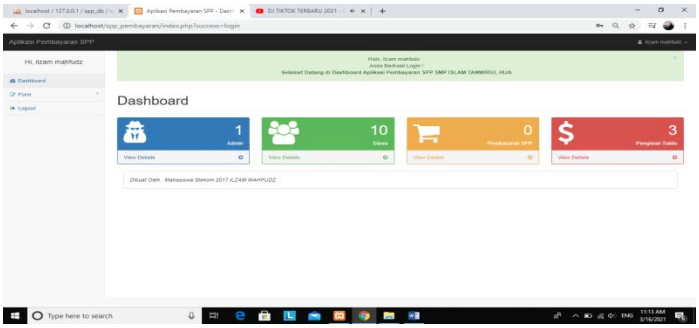

Figure 3. Dashboard View

Figure 3. describe dashboard view. Dashboards is a user interface that is quite unique, located between data and design. Displays various metrics, numbers or data visualizations. The main purpose of dashboards is to help users to make accurate and fast decisions based on existing data.

c. Admin Form Display

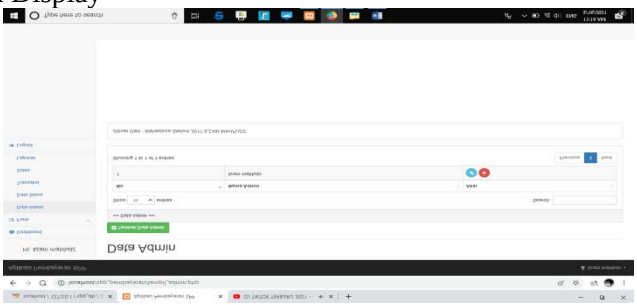

Figure 4. Admin Form Display

Figure 4. describe admin form display. The admin form functions to display admin data, at the same time in this form you can also change or add admin data.

d. Display Add Data Admin Form

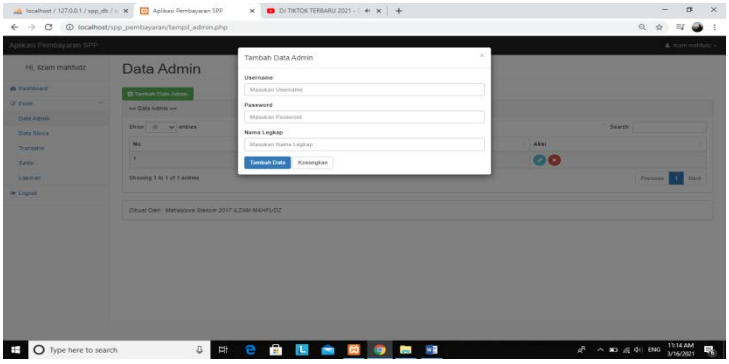

Figure 5. Display Add Data Admin Form

Figure 5. describe display add data admin. FormThe add admin data form functions to add admin data including a username and password that works when logging in. Full name serves to find out the admin's name

e. Transaction Data Display

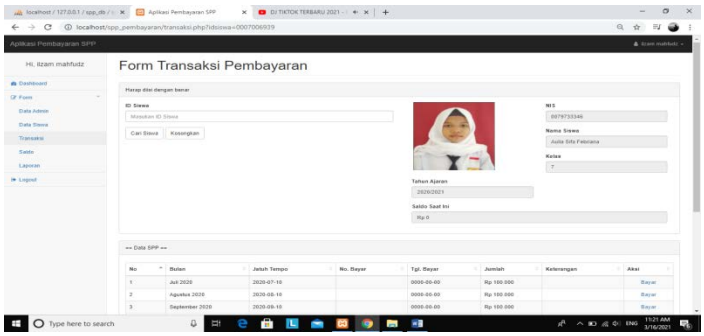

Figure 6. Transaction Data Display

Figure 6. describe transaction data display. The display of the form above will appear after the rfid card is read, the data will appear which will display personal data as well as spp data showing spp payment data.

4. Conclusion

The conclusions made refer to the purpose of making this research and after direct research is carried out, the following conclusions can be drawn: Currently, SMP X students don't have to worry about making payment transactions that are difficult and inefficient. Because now in carrying out tuition payments it is easier and faster to use e-money, students just scan the barcode and send proof of payment to the admin, the payment has been completed. Concerns about the school's data loss and difficulties in finding tuition payment data will be resolved. Because with the database, every payment will be stored and maintained and there is no need to be difficult to find it. Because on every student card there is already a student ID which, when affixed to the rfid sensor, will display clear and simple payment data.

References

[1] G. Kale and S. Dube, "Web based E-wallet Canteen Management System using RFID," *Int. Res. J. Eng. Technol.*, 2020.

[2] A. Mulyana and H. Wijaya, "Perancangan E-Payment System pada E-Wallet Menggunakan Kode QR Berbasis Android," *Komputika J. Sist. Komput.*, 2018.

[3] P. Parkhi, S. Thakur, and S. Chauhan, "RFID-Based Parking Management System," *Int. J. Adv. Res. Comput. Commun. Eng.*, 2014.

[4] S. Rakasiwi and Haryo Kusumo, "Sistem Pendukung Keputusan Pemilihan Bedak Wajah Dengan Metode Simple Additive Weighting (SAW)," *J. Teknol. Inf. DAN Komun.*, 2020.

[5] B. Siregar, N. Munawar, Seniman, and Fahmi, "Cashless payment system using RFID with NRF24L01 communication," 2020.

[6] W. A. Syafei, A. F. Listyono, A. S. Prayogi, D. Darjat, and A. Hidayatno, "Pengembangan Perangkat Lunak Untuk Gerbang Tol Otomatis Yang Ramah Lingkungan Berbasis RFID Dengan Notifikasi Pembayaran Tanpa Kertas," *TEKNIK*, 2019.

[7] S. A. Utomo, D. Utomo, and B. W. Yohanes, "Sistem e-money berbasis Contactless Smartcard

dengan Teknologi RFID," *Techné J. Ilm. Elektrotek.*, 2016.
[8] P. Verma, A. Kumar, and S. Chachada, "Enhancing Security of Contactless Payment Using RFID and GSM," *Int. J. Comput. Appl. Technol. Res.*, 2018.
[9] A. Wibowo, "Transaksi Pembayaran T-Cash dengan Dukungan Teknologi Berbasis Near Field Communications (NFC)," *Appl. Inf. Syst. Manag.*, 2018.
[10] N. Ya'Acob *et al.*, "A Cashless Payment Transaction (CPaT) using RFID technology," *Indones. J. Electr. Eng. Comput. Sci.*, 2019.

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Information System Supply Chain Management with FIFO Perpetual Method

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Abstract: Inventory is one of the assets that has an important role for the activities of a company. Problems that often occur in inventory are at the time of recording and evaluating inventory. Generally, the recording is not detailed or even manual, thus making inventory reports unclear and not good. This study aims to improve inventory management and report presentation by implementing a Supply Chain Management (SCM) information system using the Pertetual FIFO method at PT. Von Mustika. This system is built using the PHP programming language and MySQL database which functions to overcome the problem of inventory management and report presentation at PT. Von Mustika. The result of this research is that the company's report recording will be more detailed, the report will be more clear, effective and efficient to control the value of inventory and inventory expenses in real time so that the company's decision making is done quickly and accurately.

Keywords: Information System, Supply Chain Management, Pertetual FIFO, Inventory Report

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1. Introduction

Inventory is one of the assets that has an important role for the activities of a company [1]. Problems that often occur in inventory are at the time of recording and evaluating inventory [2]. Generally, the recording is not detailed or even manual, thus making inventory reports unclear and not good. The development of information and knowledge technology has progressed very rapidly [3]. This is because information has a very important role in creating advances in information technology in all fields of business. An information system is defined as a set of interrelated components that collect , process, store, and distribute information to support decision making and control in an organization [4].

PT. Von Mustika Sejahtera, which is a company engaged in the distributor and retail of ornamental plants in the form of orchids, having its address at Ruko Gor Mugas, JL. Tri Lomba Juang No. 7, Mugassari Village, South Semarang District, Semarang City. PT. Von Mustika Sejahtera was established in 2017. From the results of observations at PT. Von Mustika Prosperous transaction management -

accounting transactions still use manual processes, namely book recording and Microsoft excel, including the management of inventory records. PT. Von Mustika Sejahtera Semarang determines the value of the ending inventory, from the results of processing the daily transaction evidence that is recapitulated, then from the final amount per item of orchid flowers is inputted into Microsoft excel.
The problems that occur in PT. Von Mustika Sejahtera at the time of presenting the inventory report, including recording sales, purchases, and double recording during the recapitulation process of transaction evidence carried out by employees[5]. This can allow the results of the ending inventory value and inventory expense to be greater or less which will affect the financial statements. With manual inventory recording, it takes a long time to determine the ending inventory [6]. So that the decision-making process related to inventory takes a long time [7].

In this work, we learn that there are many problems that occur in the manual reporting system that has been used by PT. Von Mustika.The solution that the company can do is to design and create an information system using Supply Chain Management (SCM)) [8]. Supply Chain Management is needed by companies that have led to management with a just-in-time system, because the just-in-time concept emphasizes the timeliness of the arrival of materials from suppliers to consumers according to a set schedule so that they are able to record inventory which includes the recording process, summary, reporting of existing transaction activities in the company so that the presentation of reports is more timely, accurate and relevant [9]. The method that can be applied in the inventory recording process is by using the perpetual method and to determine inventory valuation using the FIFO (first-in, first-out)method.

2. Methods

2.1. Inventory Valuation Method

Inventory is a current asset in a company. If the company is a trading company, inventory is defined as merchandise held for sale in the normal operations of the company. Meanwhile, if the company is a manufacturing company, inventory is defined as raw materials contained in the production process or stored for the production process. In assessing the inventory used, there are methods, including: First In First Out (FIFO) and Average. FIFO is a method that assumes that the first item in is the first item out, while the Average consists of a Weight Average and a Moving Average [10]. Table 1. describe data transaction, Table 2. describe FIFO Method

Table 1. Data Transaction

Date	Transaction	Unit	Cost/Unit	Selling Price/unit
	Balance	800	6	4.800
4	Purchase	200	7	1.400
10	Purchase	200	8	1.600
11	Sell	800		
12	Purchase	400	8	3.200
20	Sell	500		
25	Purchase	100	8	800
28	Purchase	600	9	5.400

Table 2. FIFO Method

Date	in			out			balance		
	Q	P	T	Q	P	T	Q	P	T
Feb 1							800	$6	4.800
4	200	$ 7	1.400				800	6	4.800
							200	7	1.400
10	200	8	1.600				800	6	4.800
							200	7	1.400
							200	8	1.600
11				800	6	4.800	200	7	1.400
							200	8	1.600
12	400	8	3.200				200	7	1.400
							600	8	4.800
20				200	7	1.400			
				300	8	2.400	300	8	2.400
25	100	8	800				400	8	3.200
28	600	9	5.400				400	8	3.200
							600	9	5.400

2.2. Inventory Recording Method

To support inventory reporting, several inventory recording methods are used, namely: the Periodic Method and the Perpetual Method.

The Periodic method is an inventory mutation that does not use an inventory ledger, but uses an estimate of purchases, purchase returns, sales, sales returns and so on. This method does not use a stock card. Inventory costing is calculated by determining the ending inventory first through physical calculations, followed by calculating the Cost of Goods Sold [11], while the Perpetual Method is inventory mutation using inventory estimates. This method uses inventory cards in the calculation of inventory costing. Cost of Goods Sold (HPP) is calculated every time a sale occurs by determining the cost flow [12].

3. Results and Discussion

3.1. Context Diagram Created for the system

Context diagram is a diagram that describes the relationship between External Entities and the system to be built, where the data entered by the external component will be processed in the system and will produce the desired report by the external component in accordance with the data entered.

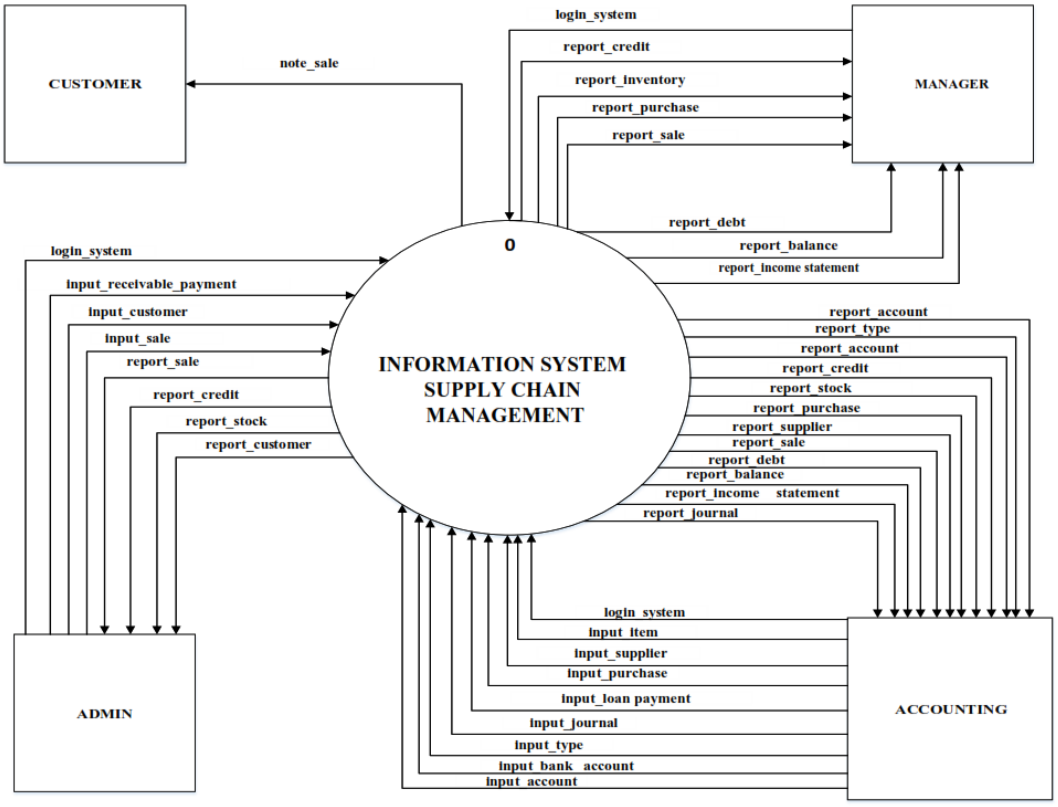


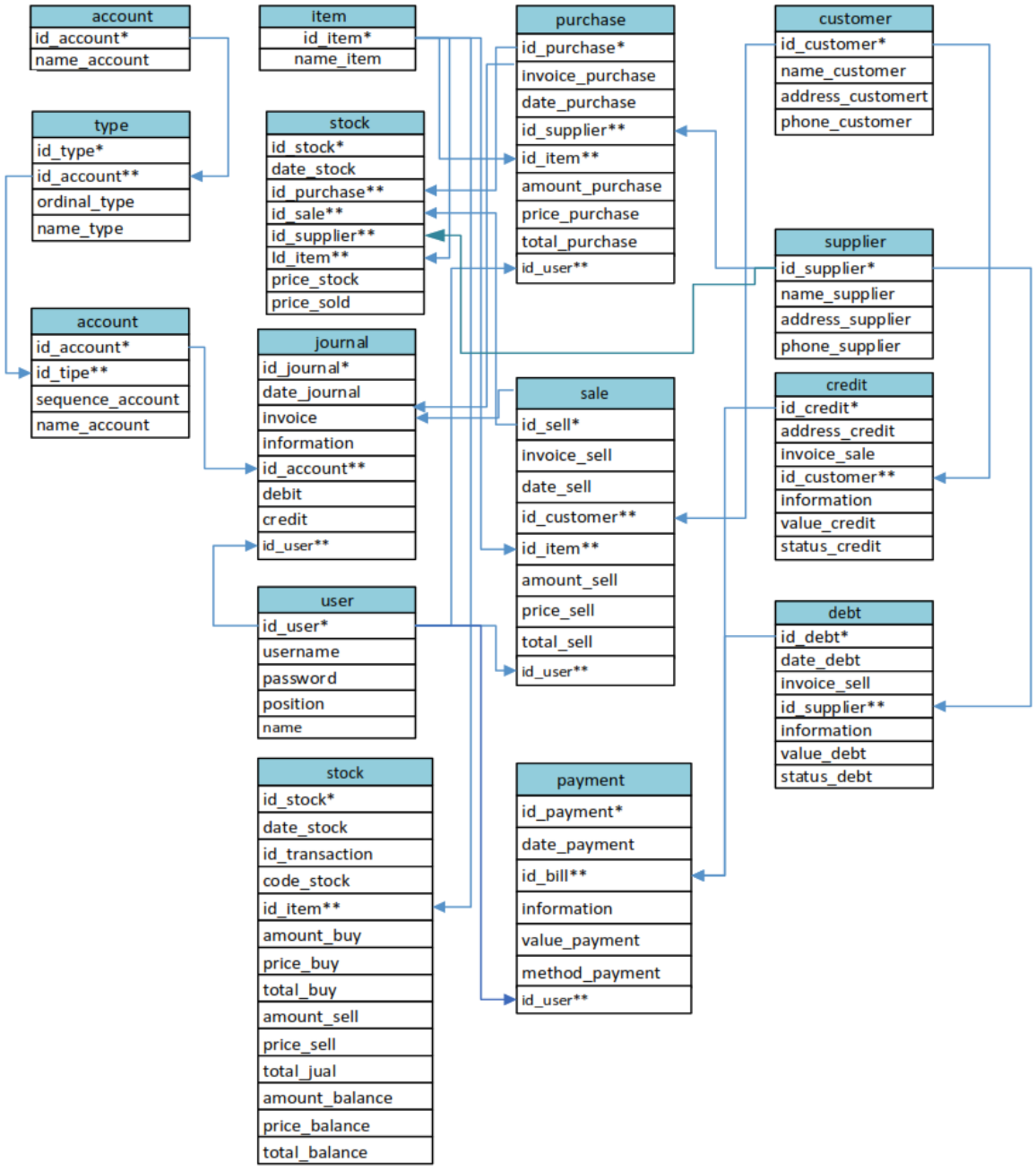
Figure 1. Context Diagram

in Figure 1. it is explained that the Customer Entity receives data flows in the form of data flows from the system in the form of sales notes. The leading entity receives data flows from the system in the form of accounts receivable reports, accounts payable reports, inventory reports, purchase reports, sales reports, balance reports, income statements. The admin entity receives and provides data flow to the system. The data flow given by the admin entity to the system is in the form of customer input, sales input, and receivable payment input. The flow of data received by the admin from the system is in the form of sales reports, accounts receivable reports, inventory reports. Accounting entities receive and provide data flow to the system. The data flow given by the accounting entity to the supplier input system, purchase input, account input, type input, account input, goods input, debt payment input, journal input. The flow of data received by accounting from the system is in the form of sales reports, purchase reports, inventory reports, accounts payable reports, accounts receivable reports, profit and loss reports, balance reports, journal reports.

3.2. Normalization Form III used in the system

The Table 3 is the third normal table, meaning that each table has a relationship between tables

Table 3. Normalized Form III



3.3. Implementation

Based on the system design that has been designed in the previous chapter, the following is an implementation of the system that has been designed. This system is implemented using a web programming application as follows:

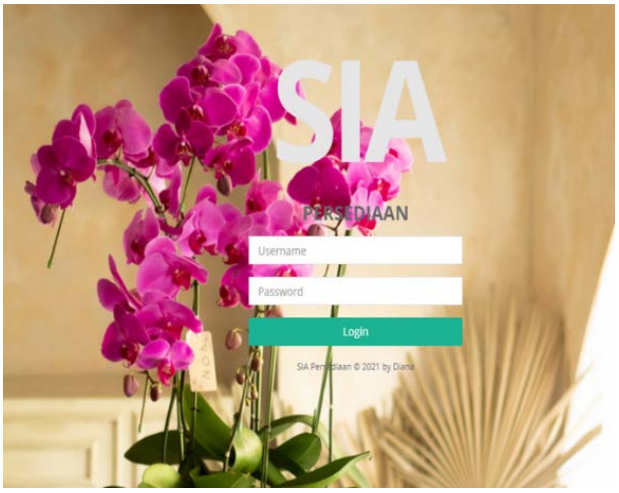


Figure 2. Login Page

Figure 2. describe login page. This login page is the first form / page before entering the main menu page of the system by entering the username and password of each user. Access rights consist of 3 users.

a. Leaders only have access rights to view reports of accounts receivable, accounts payable, inventory, sales, purchases, balance sheets, profit and loss.
b. Admin has access rights to input customer data, sales transactions, receivable payment transactions, inventory reports, sales reports, accounts receivable reports.
c. Accounting has full access rights except for sales transactions, receivable payment transactions, and customer data input.

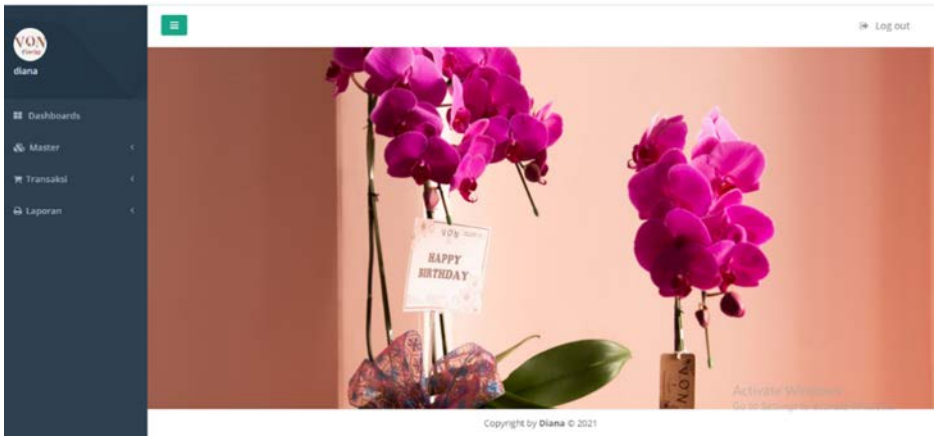


Figure 3. Main Menu Page

Figure 3 describe main menu page. The main page is a page that displays the system's main menu which consists of submenus. If the user is logged in, this page will appear.

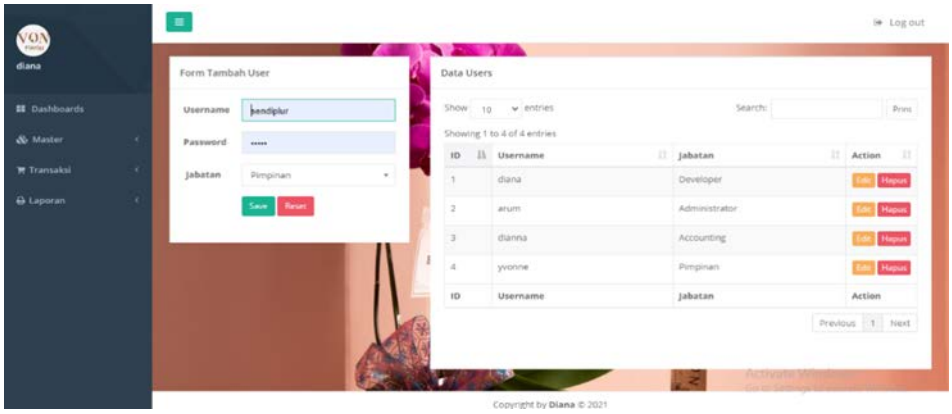


Figure 4. User Form

Figure 4. describe user form. The user form is used to add a new user in order to access the inventory information system. Here is the view of the user form.

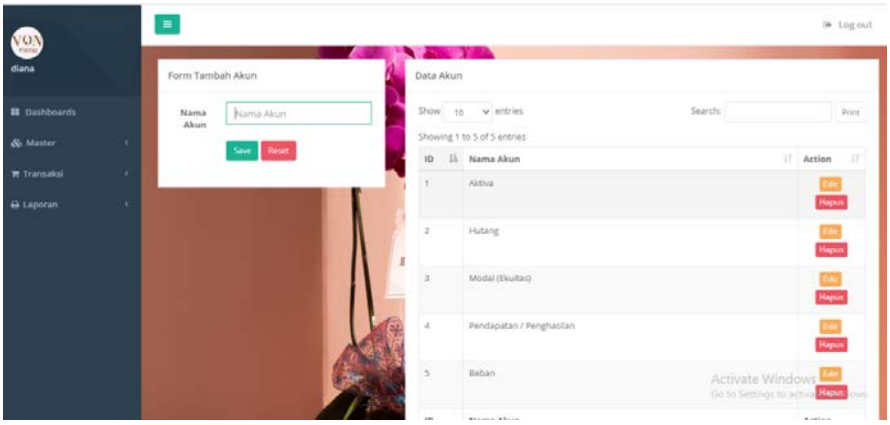


Figure 5. Account Form

Figure 5. describe account form. This account form is used for account names such as assets, income, expenses, capital payables.

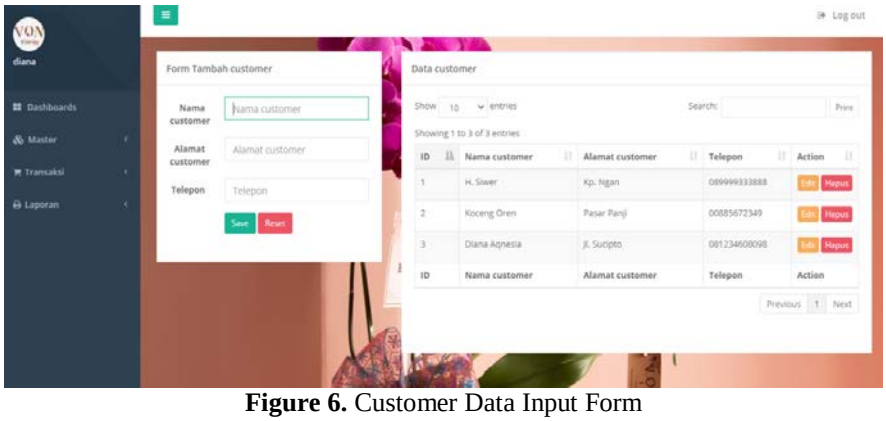


Figure 6. Customer Data Input Form

Figure 6. describe customer data input form. Form type is used to input account data type. And a sub-account, such as an asset account, will then be classified into 2 types, namely current assets and fixed assets.

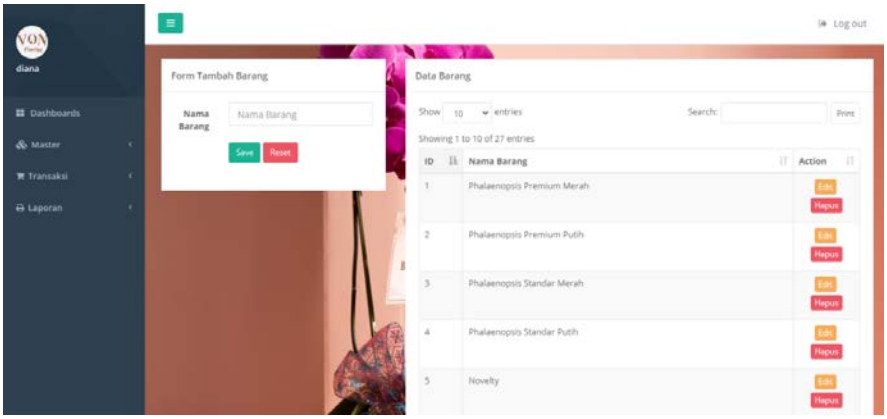


Figure 7. Item Data Input Form

Figure 7. describe item data input form. This account form is used to input account data that will be used in the transaction process and also reports on this inventory information system, for example: cash, inventory, accounts payable, sales, etc.

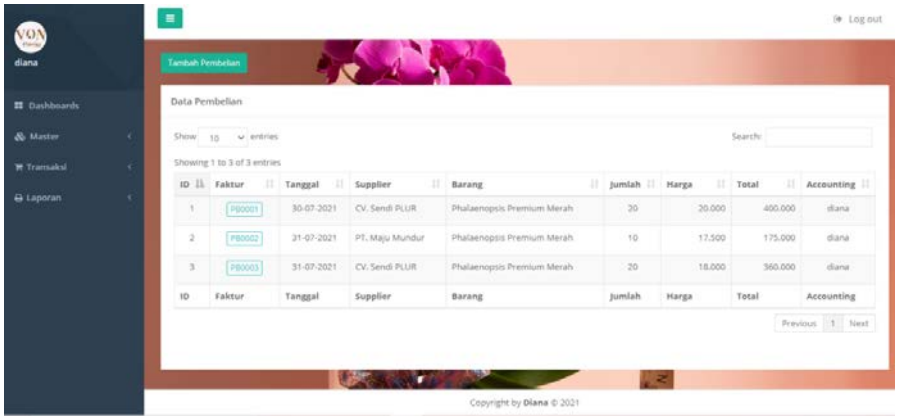


Figure 8. Purchase Form

Figure 8. describe purchase form. This form is used to input supplier data. This supplier data will be used in purchase transactions and debt payments

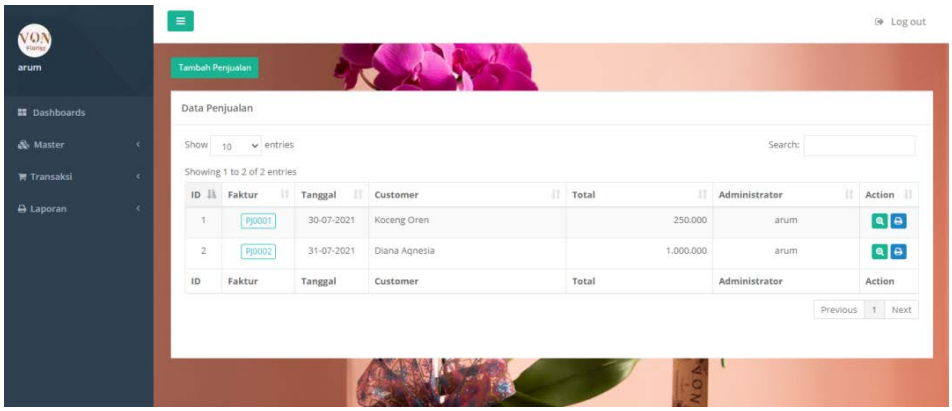


Figure 9. Sales Form

Figure 9. describe sales form. The sales form is used to input sales transactions, on the sales transaction form there is an add item button that is used to enter sales transactions.

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INVENTORY CARD

RED PREMIUM PHALAENOPSIS

09/01/2021-09/30/2021

Date	Purchase			Sell			Balance		
	Qty	Price	Total	Qty	Price	Total	Qty	Price	Total
01-09-2021	25	100.000	2.500.000	0	0	0	25	100.000	2.500.000
02-09-2021	10	105.000	1.050.000	0	0	0	25	100.000	2.500.000
02-09-2021	0	0	0	0	0	0	10	105.000	1.050.000
03-09-2021	0	0	0	25	100.000	2.500.000	0	100.000	0
03-09-2021	0	0	0	5	105.000	525.000	5	105.000	525.000
04-09-2021	10	110.000	1.100.000	0	0	0	5	105.000	525.000
04-09-2021	0	0	0	0	0	0	10	110.000	1.100.000
07-09-2021	0	0	0	5	105.000	525.000	0	105.000	0
07-09-2021	0	0	0	0	0	0	10	110.000	1.100.000

Figure 10. Inventory Form

Figure 10. describe inventory form. Inventory report form is used to display inventory cards using the FIFO Perpetual method for inventory control. To view the inventory report, you must enter the start, end date of the report, and select the name of the item to be printed. Inventory reports use the FIFO valuation method, in this method the goods that enter first are the goods that must go out first

4. Conclusions

With the Supply Chain Management information system FIFO Perpetual method for inventory management, report presentation becomes clearer, more effective and efficient. This system allows every transaction to be recorded in inventory value and inventory expense, then it will be entered into the inventory, balance and profit and loss reports so that it can facilitate the admin in internal control of inventory. This system facilitates staff performance so that it can shorten the reporting process time because all staff can access the required reports according to access rights. This system makes it easy to control inventory values and inventory expenses in real time so that decisions can be made quickly and accurately.

References

[1] A. Saidatul, "Sistem Informasi Akuntansi Persediaan Obat Menggunakan Metode FIFO Perpetual Pada UTD Puskesmas Brangsong 02," *KOMPAK*, 2017.

[2] S. Bradshaw, H. Bailey, and P. N. Howard, "Industrialized Disinformation 2020 Global Inventory of Organized Social Media Manipulation," *Comput. Propag. Res. Proj.*, 2020.

[3] Y.-S. Chao, A. Sinclair, A. Morrison, D. Hafizi, and L. Pyke, "Canadian Medical Imaging Inventory, 2019–2020," *Can. J. Heal. Technol.*, 2021.

[4] L. G. K. Dewi, N. L. P. S. Dewi, and P. A. K. D. Putri, "Analisis Pengendalian Intern Persediaan Barang Dagang dan Penerapan Akuntansi pada PT. Indahwati Sari," Widya Akuntansi dan Keuangan., 2020.

[5] D. Kartinah and T. Kuncara, "Analysis Of The Application Of Recording Methods And Assessment Of Inventories In Accordance With Psak No. 14 At Andrew Smith Urban Lifestyle Supermall Karawaci," *Int. J. Sci. Technol. Manag.*, 2021.

[6] C. Dwiprastio, M. Karismariyanti, and R. Sukawati, "Aplikasi Penjualan dan Persediaan Barang Dagang dengan Metode Perpetual FIFO Berbasis Web (Studi Kasus pada PD. XYZ)," *J. Teknol. Inf.*, 2012.

[7] G. A. Hengkeng, S. S. Pangemanan, and J. D. . Waronggan, "Evaluasi Penerapan Akuntansi Persediaan Obat Berdasarkan Psak No. 14 pada PT. Cempaka Indah Murni Manado," *Going Concern J. Ris. Akunt.*, 2020.

[8] I. Irawati, S. Martadinata, and M. Nurjihadi, "Evaluasi Penerapan Akuntansi Persediaan Pada Pt Xyz Cabang Sumbawa Besar," *J. Ekon. dan Bisnis Indones.*, 2017.

[9] H. Kusumo, "Pengaruh Budaya Organisasi Dan Motivasi Kerja Terhadap Kinerja Karyawan Dengan Komitmen Organisasi Sebagai Variabel Moderasi Pada Stekom Semarang," *J. Nusant. Apl. Manaj. BISNIS*, 2017.

[10] W. Ryan, "Selecting an Inventory Costing and Valuation Method.," *New Jersey CPA*, 2012.

[11] S. K. Samal, "Logistics and supply chain management," *Int. J. Psychosoc. Rehabil.*, 2019.

[12] S. Zhang, K. Huang, and Y. Yuan, "Spare parts inventory management: A literature review," *Sustain.*, 2021.

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Market Basket Analysis for Determination of Consumer Behavior at XYZ Stores Using R Programming

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Abstract. Data mining is one of the fields of science in the world of informatics which has an important role, especially with regard to data. There are many algorithms and methods that can be used to process data. The paper this time the author tries to conduct research on consumer behavior by using one of the data mining techniques, namely market basket analysis. This research uses the R Programming tool, where it is hoped that the research can be carried out effectively and efficiently. Based on the research conducted, it is known that there has been a significant purchase of several items that have been described as a plot. The tendency of consumers to buy several items followed by other items can be a consideration for arranging the layout of goods on the sales shelf or arranging product stock in a supermarket.

Keywords: Data Mining, Market Basket Analysis, Plot, R Programming

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1. Introduction

The world of marketing is growing and business competition is inevitable. In a supermarket, there is often a problem with the absence of stock in certain products. This results in consumer disappointment if it lasts for a long time, moreover, these products are in great demand by consumers. Therefore it is necessary to have good marketing management so that the fulfillment of consumer needs can be fulfilled. Research on product sales analysis has been carried out under the title Data Mining Estimated Banner Production Using the Apriori Algorithm (Case Study: CV. Mentari Persada Medan) in this research it is known that the most production of banners is Satin and Ritrama stickers, with a priori algorithm so you can see the types The most widely produced banners that meet support and minimum confidence.[1]
Another study conducted data mining implementation on medical equipment supplies entitled Implementation of Apriori Data Mining Algorithms in the Medical Equipment Supply System. In his research, it is known that the application of a priori algorithm in data mining techniques is very efficient and can accelerate the process of forming a trend of itemset combination patterns from the sale of medical devices at the Kelambir-2 Pharmacy in Medan, with the highest support and confidence is Uric Acid Stick - Sugar Stick and Colestrol-Stick Sugar.[2] Pasaribu conducted research with the title

Decision Support System for Analysis of Sales Patterns of Goods Using the Apriori Algorithm (Case study: Lucky Swalayan). In his research, Pasaribu created a program that can be used to process a large number of sales data into an alternative decision that can help supermarket owners see which products are often purchased by consumers and can also be used to assist in arranging the layout of goods at the supermarket so that the goods are frequently purchased.[3] Consumers buy simultaneously can be placed close together, while items that are rarely purchased can be given discounts to attract consumers. In research conducted by Ari and Laili, the system development model is carried out using a prototype where customers and users will be directly involved in the process where the research results are in the form of transaction data analysis using market basket analysis with 4 product combinations based on the largest support x confidence value. with the results in the form of numbers of possible transactions related to the products sold**.**[4]

Rina et al conducted a study entitled Perancangan Market Basket Analysis Menggunakan Association Rule untuk Pendukung Keputusan Promosi pada Sistem Penjualan Sun Young Cell. This study aims to design Market Basket Analysis for sales system at Sun Young Cell as a sales transaction information processing application which can provide analytical results representing sales rates according to trends in certain product sales. The technique used is association rule that describes the patterns of transaction by using rules to support decision making process. [5]

Based on this background and referring to previous research, the author is interested in conducting research with the title Market Basket Analysis to Determine Consumer Behavior Using R Programming.

2. Basic of Theory

2.1. Data Mining

Data mining is a process in making decisions by looking for patterns of information contained in data. Pattern search can be done using a query or with the help of certain applications so that it can automatically search for patterns in a database. Data mining is also a step in the Knowledge Discovery in Databases process.[6]

There are several data mining techniques as follows :[7]

1. Classification

Defines a new data record into a previously defined class.

Some of the applications of calcification are:

- Direct sales
- Fraud Detection
- Customer Attrition (Churn)

2. Clustering

It is unsupervised learning in which the data set is partitioned into groups so that the elements have a shared set of properties with a high level of similarity within one group, while between groups has a low level of similarity.

The applications of clustering are:

- Market segmentation
- Document clustering

3. Association Rule

Detect a set of attributes that occur together in frequent frequencies and form a number of rules from these sets.

The applications of the association rule are:

- Marketing and sales promotion
- Supermarket shelf management
- Inventory management

4. Sequential Patern

Look for a number of events that generally occur together.

5. Regression

Predict the value of a given continuous variable based on the value of the other variable based on the assumption of linear or nonlinear dependence.
6. Deviation Detection
Perform anomaly detection automatically to identify the habits of an entity and establish a number of norms through pattern discovery.

2.2. Market Basket Analysis
Shopping basket analysis or market basket analysis is a discussion in data mining which aims to determine the relationship between products purchased by consumers in one transaction. In the market basket analysis, we will find out what products consumers often buy at the same time.
With the existence of a market basket analysis, it will be possible to know the pattern of purchases that occur so that it is expected to be able to help supermarkets and marketing businesses to maximize the arrangement of goods and inventory

2.3. Association Rule Analysis
Is a procedure in Market Basket Analysis that is used to find relationships between items in a data set and display them in the form of Association Rules. The function of Association Rules is often called “market basket analysis”, which is used to find the relation or correlation between a set of items2. The type of association rule can be stated for example: "70% of the people who buy noodles, juice and sauce will also buy plain bread".
Association rules capture items or events in large data sets containing transaction data.
With advances in technology, sales data can be stored in large amounts called "data basket."
The association rules defined in the data basket are used for promotional purposes, catalog design, customer segmentation and marketing targets.

2.4. R Programming
R programming is a programming language that can be used to perform data manipulation, simulation, calculation and graphic display. R has the ability to analyze data very effectively and is equipped with array and matrix processing operators. R also has the ability to display graphics that are very sophisticated as well as modeling for his data. The R language is similar to the S language developed by Rick Becker, John Chambers and Allan Wilks at AT&T Bell Laboratories.[8]
Software R is an open-source software from the commercial version of the S programming language based on the S language is S plus. Software R has the capability that is not inferior to commercial data processing packages, even in some ways its capabilities are much better. The R language has not been widely known by the Indonesian people but the R language has received a good response from statisticians around the world. Apart from being open source, the R language also has other advantages, namely that it is multi-platform so that it can run on various operating systems. The R language also has thousands of packages that can be used as needed and can be developed via github or the developer version

3. Methods
3.1. Research Methods and Data Collection
In this study the authors used a descriptive research method because in this study a number of facts will be presented. The research that will be carried out begins with formulating the problem, then conducts a literature review by referring to references to previous studies. Then, data will be collected through secondary data which is taken for analysis using R Programming.
The results of the shopping cart analysis that has been carried out with R Programming will be displayed in the form of a plot, so that the patterns of consumer purchases that occur will be seen. The next step is to arrange the research flow so that the research runs according to the steps determined by the author with the hope that the research will run smoothly and the research results can be maximized.

3.2. Data analysis

The research carried out took secondary data so that the existing data would be further analyzed as a shopping cart analysis so that the support and confidence were determined first. From determination

3.3. Research Flow

The research flow carried out by the author is as follows:

a. Retrieving secondary data
b. Save data into csv
c. Open R Programming and load the required libraries
d. Perform shopping cart analysis process
e. Visualization of analysis results'

The research flow is described as in Figure 1.

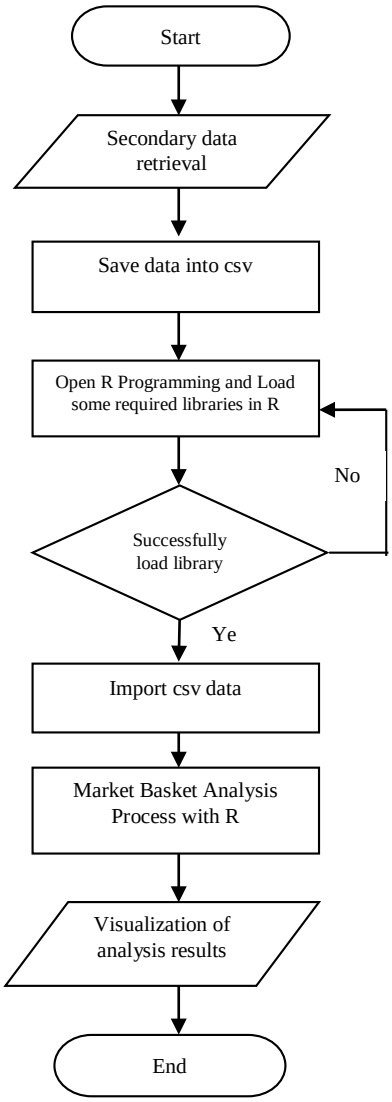

Figure 1. Research Flow

4. Results and Discussion

4.1. Problem analysis

Some of the problems that arise in the marketing world, especially retail, are a shortage of stock of goods and improper placement of goods that affect purchasing patterns. Starting from a problem like this, an analysis of the buying pattern can be carried out with a shopping cart analysis.

4.2. Sales Itemset Data

The following is sales data which is used as a shopping cart analysis.

citrus fruit semi-finished bread
tropical fruit yogurt
wh ole milk
pip fruit yogurt
other vegetables whole milk
whole milk butter
rolls / buns
other vegetables UHT-milk
pot plants
whole milk cereals
tropical fruit other vegetables
citrus fruit tropical fruit
beef
frankfurter rolls / buns
chicken tropical fruit
butter sugar
fruit / vegetable juice
packaged fruit / vegetables
chocolate
specialty bar
other vegetables

The data item above is a sample item from a number of 10,000 existing transactions. By observing the existing transaction data, it can be seen that several items are the same, which means that when someone buys item A, he also buys items B, C and so on.

When described in mathematics are:

- Item set: I = {i1, i2,…, in}
- Transaction: tn = {ij, ik, ..., in}
- Rules: {i1, i2} => {ik}

If we describe it further, it is as follows:

"If someone buys an item in the item set on the left, that person will also buy the item on the right."

{coffee, sugar} => {milk}

When a consumer buys coffee and sugar, he also buys milk.

From this it can be seen that there are three important things in association rules, namely:

- Support: shows the percentage of the number of transactions that contain the item.
- Confidence: shows the percentage contained in transactions containing items
- Lift ratio: is an important parameter besides support and confidence. The lift ratio measures how important the rule is based on the value of support and confidence.

4.3. Market Basket Analysis with R

To perform shopping cart analysis using R Programming, all you have to do is install the necessary libraries, then load the libraries. The packages required are rules, arulesviz and datasets. The process and load results from the three libraries are shown in Figure 1.

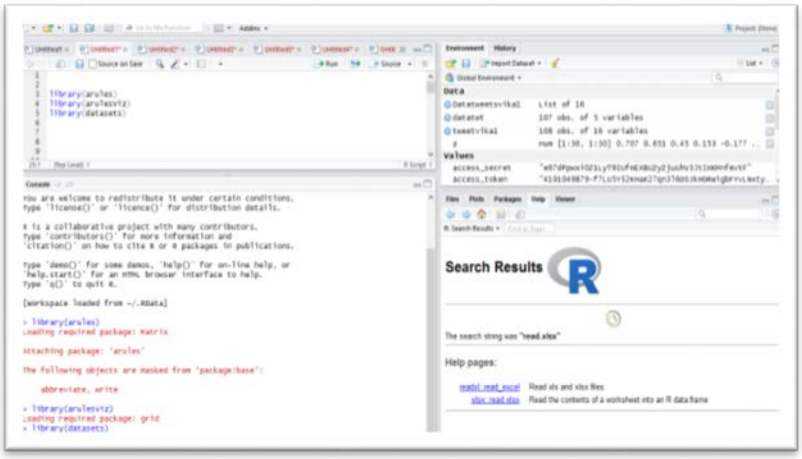

Figure 1. Load Library on R

After the load library process is successful, the next step is to import the data used for shopping cart analysis, how R imports the data shown in Figure 2.

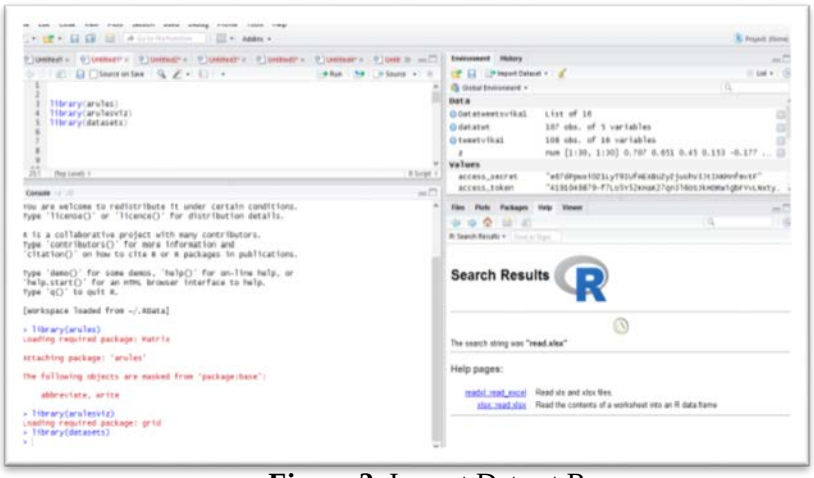

Figure 2. Import Data at R

The results of imported data are depicted in Figure 3.

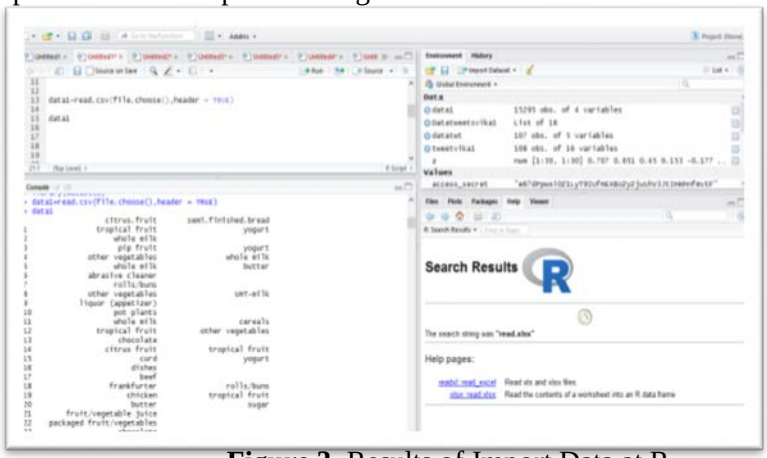

Figure 3. Results of Import Data at R

After successfully importing the data set, we plot the frequency items for the top 20 items. This is depicted in Figure 4.

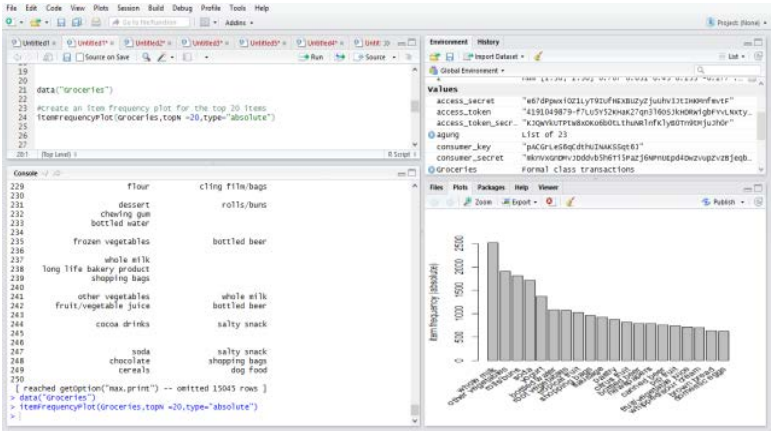

Figure 4. Process of Create Item Frequency

The results of the plot of the frequency items are as shown in Figure 5

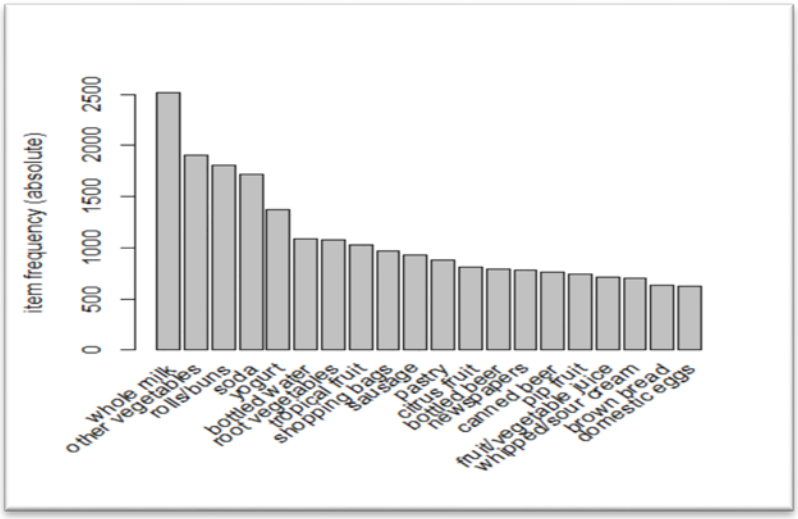

Figure 5. Item Frequency Plot

Successfully plotting frequency items for the top 20 items, the next step is to make rules, namely:

- determine the minimum support 0.001
- determine the minimum confidence 0.8
- determine the top 5 rules

this step is depicted as in Figure 6.

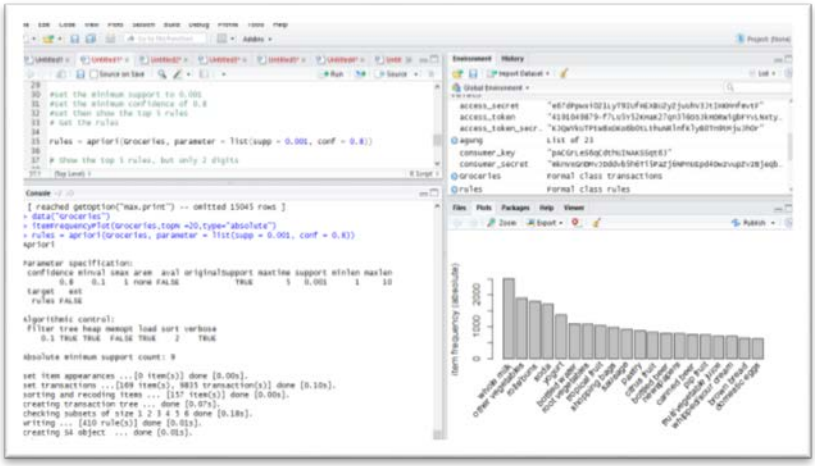

Figure 6. Top 5 Rules

Top 5 Frequency Items as shown in Figure 7.

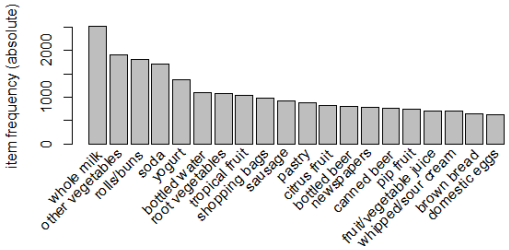

Figure 7. Top 5 Frequency Items

The output is as follows (Figure 8):

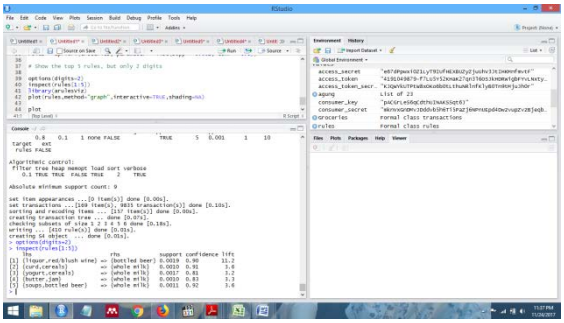

Figure 8. Output on R

Illustrated by the table can be seen in Table 1.

Table 1. Example Output

No	Lhs	Rhs	Support	Confidence	Lift
1	{liquor,red/blush wine}	=>{bottled beer}	0.0019	0.90	11.2
2	{curd,cereals}	=>{whole milk}	0.0010	0.91	3.6
3	{yogurt,cereals}	=>{whole milk}	0.0017	0.81	3.2
4	{butter,jam}	=>{whole milk}	0.0010	0.83	3.3
5	{soups,bottled beer}	=>{whole milk}	0.0011	0.92	3.6

Visualization of the results in the form of a plot (random) as shown in Figure 9.

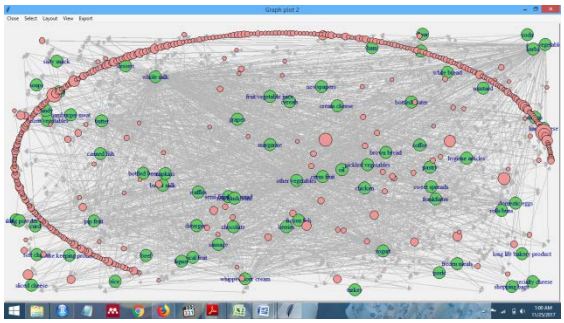

Figure 9. Visualization of Random's Layout Plot

Visualization of the results in the form of a plot (circle) as shown in Figure 10

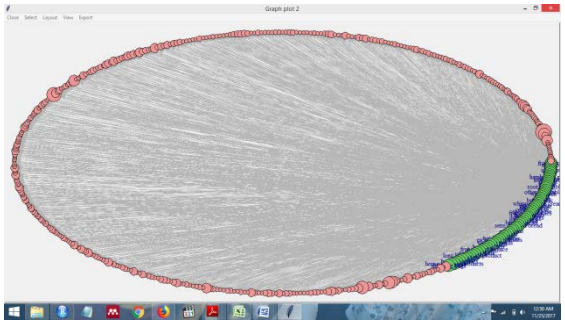

Figure 10. Visualization of Circle's Layout plot

Visualization of the Fruchterman-Reingol plot as shown in Figure 11

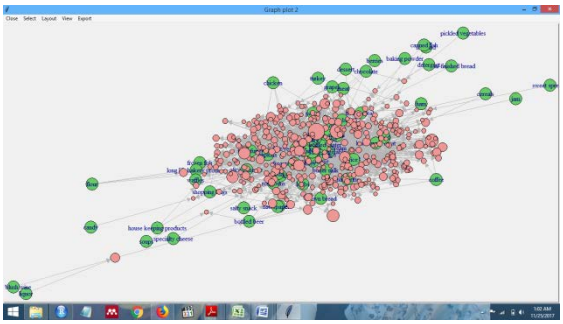

Figure 11. Visualization of the Fruchterman-Reingol plot

Visualization of Kamada Kawai Plots as shown in Figure 12.

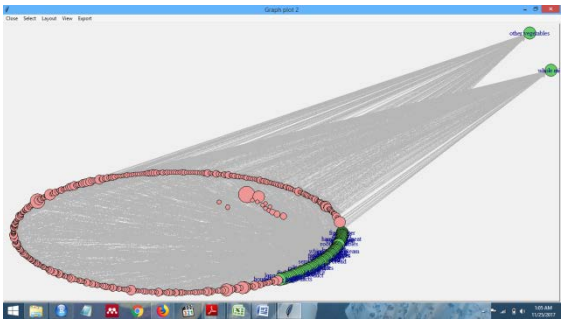

Figure 12. Visualization of Kamada Kawai Plots

Visualization of the Reingold_Tilford Plot as shown in Figure 13.

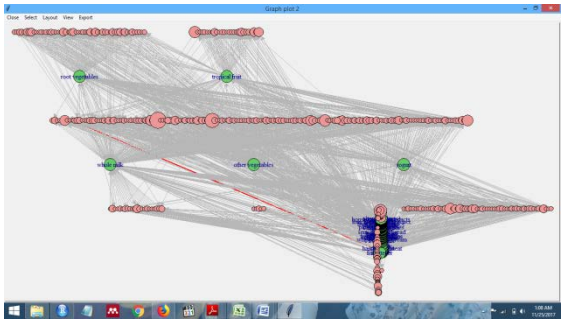

Figure 13. Visualization of the Reingold_Tilford Plot

5. Conclusions

Based on the shopping cart analysis, conclusions can be drawn:

1. The implementation and utilization of R Programming is able to make the market basket analysis process run faster and more effectively, even with very large data. This is done by utilizing the available libraries in R Programming.
2. Looking at the output results and visualization that shows the patterns that occur in transactions can be known quickly, for example, as in no.3 table 1, that consumers who buy yogurt are certain 81% also buy whole milk, and so on.

During the analysis process, there were several obstacles faced, one of which was when running R Programming experienced an error in program execution. This research is built on the author's assumptions and conclusions and visualization are still not optimal.

The author provides suggestions to the next researcher to make improvements in related research, a more interactive visualization can be added and the output may be added to how the layout of goods at supermarkets or retail is able to attract consumer interest and increase sales productivity.

References

[1] Dewi Puspitasari, “Data Mining Perkiraan Produksi Spanduk Dengan Algoritma Apriori (Studi Kasus: CV. Mentari Persada Medan),” vol. IX, Mar. 2015.

[2] K. Tampubolon, H. Saragih, B. Reza, K. Epicentrum, A. Asosiasi, and A. Apriori, “Implementasi Data Mining Algoritma Apriori Pada Sistem Persediaan Alat-Alat Kesehatan,” *Inf. dan Teknol. Ilm.*, pp. 93–106, 2013, doi: 2339-210X.

[3] Safar Riduan Pasaribu, “Sistem Pendukung Keputusan Analisa Pola Penjualan Barang Dengan Algoritma Apriori (Studi Kasus: Lucky Swalayan),” *Pelita Infomatika Budi Darma*, vol. VI, no. Nomor 2, Apr. 2014.

[4] A. Muzakir and L. Adha, “Market Basket Analysis (Mba) Pada Situs Web E-Commerce Zakiyah

Collection," *Simetris J. Tek. Mesin, Elektro dan Ilmu Komput.*, vol. 7, no. 2, p. 459, 2016, doi: 10.24176/simet.v7i2.755.
[5] R. Halim and P. A. Jusia, "Perancangan Market Basket Analysis Menggunakan Association Rule untuk Pendukung Keputusan Promosi pada Sistem Penjualan Sun Young Cell," vol. 12, no. 1, pp. 974–983, 2017.
[6] Sri Rahayu SIregar, "Implementasi Data Mining Pada Penjualan Tiket Pesawat Menggunakan Algoritma Apriori (Studi Kasus: Jumbo Travel Medan)," *Pelita Inform. Budi Darma*, vol. VII, no. Nomor 1, Jul. 2014.
[7] Fajar Astuti Hermawati, *Data Mining*. Yogyakarta: Andi Offset, 2013.
[8] "www.r-project.org," Feb. 19, 2021. .

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Activity of *Moringa oleifera* seed ethanolic extract against *E. coli*

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Abstract. Bacterial contamination in our environment is worrying, mainly contamination at drinking waters, vegetables, foods, soil which close to our daily activity. The main contamination in environment is caused by *E. coli* which simply found easily surround us. So, it leads to bigger problem if not immediately solve. One of possible yet safe compounds to overcome this problem is the use of natural product such as *M. oleifera* seeds as antibacterial agents. This study want to find out the ability of *M. oleifera* seed ethanolic extract as antibacterial agent against *E. coli*. Ethanolic extract of *M. oleifera* seeds are concentrated into 25%, 50%, and 75%, then treated to *E. coli* culture under laboratory condition. The inhibitory zone diameter which formed after 24 hours incubation was measured and compared to control with no extract treatment. The result of this study showed that there is inhibitory zone formed in three groups of treatmen (T1-T3), but there is no inhibitory zone formed at control group. The 75% ethanolic extract of *M. oleifera* seeds (T3) has the wides inhibitory zone diameter among four groups, followed by the 50% extract (T2) and 25% extract (T1) with diameter 15,03 ± 0,55 mm; 11,00 ± 1,32 mm; 7,03 ± 0,90 mm, respectively. All inhibitory zone diameter among groups in this research statistically different with strong inhibitory status at T2 as well as T3, and moderate inhibitory status at T1.

Keywords: antibacterial, *Escherichia coli*, *Moringa oleifera*

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1. Introduction

Escherichia coli is one of fecal-oral pathogens transmitted from feces or contaminated water into new host, through complex environmentally mediated pathways [1]. Those species has been implicated as diarrheagenic bacteria which outbreaks worldwide through foodborne and associated with childhood stunting [2]. With complex phylogenetic substructure, many *E. coli* are harmless but some are infectious cause intestinal and extra-intestinal infections. *E. coli* can cause serious infections via contaminated food and water occurs in healthcare unit, at home, dan during travel [3]. Contaminated water in Indonesia are one of community problem which drive to serious health problem. The present of *E. coli* in water bank such as wells, river, etc can cause serious infectious diseases in Indonesia, especially in rural area with low hygiene level. Whereas, health and productivity of community system hinge on water quality and hygiene status of society environmen [4].

The habitat of *E. coli* are primary (gastrointestinal tract) and secondary (water, sediment, soil, and flora), with negative growth rate in secondary habitat implies short-term host persistence [5]. Gastrointestinal disease which also can provided by *E. coli* contamination cause an estimated 500.000-

700.000 deaths in children under 5 years old, annualy [6]. Water sources, especially in rural area, such as wells or rivers are one of primary *E. coli* contamination sources [7]. Moreover, contamination of *E. coli* also can be found in leafy greens vegetables, such as spinach, lettuce, water spinach, etc [8]. Those fact provide more possibility *E. coli* contaminated vegetables be consumed by Indonesian society and cause an foodborne diseases. So, the control of *E. coli* contamination is necessary.

Indonesian biodiversity provide many natural product bioactive compounds in a role as antibacteria. The extraction of bioactive compounds from natural material such as plants, fungus, bacteria itself, as antibacteria has recently expanded. Plants natural compounds has many functional values for health and has been widely studied in Indonesia [9][10][11]. One of Indonesian plant bioactive compounds which purposes as antibactial is *Moringa oleifera*. It has been shown as an antimiceobial agent against different bacteria and fungi in various water studies. It also been considered as an ideal application for water contamination in developing countries [12].

Moringa oleifera with *Jatropha curcas*, *Hibiscus sabdariffa*, *Clidemia angustifolia*, and others have been known and used for water purification. The bioactive compounds of *M. oleifera* has been found as coagulation factors and acts as natural cationic polyelectrolyte causes coagulation in turbid water [13]. Moringa species have been known as antibacteria, antihelminthic, detoxifiers, immune builders [14], antipyretic, antiepileptic, antiinflamatory, antiulcerative, antihypertensive, cholesterol lowering, antioxidant, antidiabetic, and hepatoprotective [15] in folk medicine. It provides zeatin, quercetin, and many others phytochemicals properties. Based on its bioactive compounds potential, *M. oleifera* widely studied as antibacterial properties, include for *E. coli* in contaminated water due to its possibility to enhance the coagulation activity [16]. The objective of this study is to know the activity of ethanolic extract of *M. oleifera* seed as anti-*E. coli*.

2. Methods

Black seed of *M. oleifera* was separated from its peel then dried at 25-30°C. The dried black seed was mashed and ready for extraction. A 750 g sample powder was maserated with 96% ethanol for 3x24 hours, stirred every 1x24 hours. The extract was ready to filtered after 3x24 hours, then the solvent was evaporated. The concentrated extract was obtained then analyzed for antibacterial activity assay for *E. coli* isolated from water sample in Tlogosari Wetan, Semarang, Indonesia. The isolate was cultured at Mac Conkey Agar (MCA), then at Eosin Methilen Blue (EMB). Separated colony then cultured at indol media, Methyl Red (MR), Voges Proskauer (VP), and Simmon's citrate agar for biochemistry assay.

For antibacterial assay, isolated *E. coli* was inoculated at nutrient agar with pour plate method. The culture then been incubated at 37°C for 24 hours. The cultured *E. coli* was diluted into NaCl 0,9 % to 10^{-5} dilution. The 10^{-5} *E. coli* dilution then poured at sterilized petridish and analyzed for antibacterial assay. The Kirby-Bauer antibacterial assay was performed at 4 group. Group 1 is control (C), group 2 is 25% ethanolic extract of *M. oleifera* seed (T1), group 3 is 50% ethanolic extract of *M. oleifera* seed (T2), and group 4 is 75% ethanolic extract of *M. oleifera* seed (T3). Under the aseptic conditions, saturated filter paper discs were placed on the inoculated solid agar surface. After the 24 hours incubation at 37°C, the inhibition zone was analyzed. The data of inhibition zone were analyzed with SPSS 17.0 version programme. Analysis of variance (ANOVA) were performed using one-way ANOVA. Significant differences among means were determined by Duncan's test and if the P value was less than 0.05, so the datas were considered as statistically significant. The widest inhibition zone is represents the most inhibited colony of *E. coli* by ethanolic extract of *M. oleifera* seed.

3. Result and Discussion

The extraction yield was 21,35% (Table 1) from 160,14 g concentrated ethanolic extract of *M. oleifera* seed. These yield was obtained from 770 g *M. oleifera* seed. The yield percentage of EEMS was measured by ratio of concentrated extract weight (g) and simplicia weight (g) multiplied with 100%. In this study, the yield percentage of EEMS is 21,35%. The extraction was performed with maseration method. Maseration is an extraction process with specific solvent and repeated mixture at room temperature. Maseration was used due to its simple and fast process. The 96% ethanol was used for

faster evaporation of ethanol residue in the extract [17]. Ethanol is known as a efficient solvent for natural product extraction due to its higher eficiency and faster process. Ethanol is considered as universal solvent dissolving natural material compounds, non-polar, semi-polar, or polar [18]. Polarity indext of ethanol is 5,2 so polar or non-polar substances could be extracted and 96% ethanol can be use as solvent for low molecule weight of almost all substances such as saponin and flavonoid.

Table 1. Yield percentage of ethanolic extract of *M. oleifera* seed (EEMS)

Sample Weight (g)	Simplicia Weight (g)	Filtrat Volume (ml)	Concentrated Extract Weight (g)	Yield (%)
770	750	1.500	160,14	21,35

Antibacterial activity assay was performed with Kirby-Bauer method. Saturated filter paper discs was placed on culture surface then the *E. coli* culture was incubated at 37°C for 24 hours. The inhibitory zone then be measured. The result of this study showed thatethanolic extract of *M. oleifera* seed (EEMS) significantly inhibit the growth of *E. coli* under laboratory condition. Culture with 75% EEMS showed the highest inhibitory effect with 15,03 ± 0,55 mm inhibition zone diameter. It is significantly different from culture with 50% EEMS and 25% EEMS which are showed 11,00 ± 1,32 mm and 7,03 ± 0,90 mm inhibition zone diameter, respectively (**Table 2**). All of three group treated with EEMS showed wider inhibition zone diameter than control group because the culture media of control group was only added with aquades.

Table 2. The resistance status of *E. coli* with ethanolic extract of *M. oleifera* seed (EEMS) treatment

Group	Inhibition Zone Diameter (mm)	Resistance Status
C	$0,00 \pm 0,00^{a}$	Low
T1	$7,03 \pm 0,90^{b}$	Moderate
T2	$11,00 \pm 1,32^{c}$	Strong
T3	$15,03 \pm 0,55^{d}$	Strong

Note: The symbol C is control (aquades); T1 represents 25% of EEMS treatment; T2 represents 50% of EEMS treatment; and T3 represents 75% of EEMS treatment

The resistance status of EEMS for the growth of *E. coli* are low at control group, moderate at T1, strong at T2 and T3. This result indicate the ability of EEMS to inhibit the growth of *E. coli* so this natural resources could be utilized as antibacterial agent to overcome the soil, water, or other pollution sourced by *E. coli* contamination. This result is supported by previous research which showed that *M. oleifera* seed oil has 40,17 ± 0,01 mg GAE/g total phenol compound, 18,24 ± 0,01 mg RE/g total flavonoid compound, and 37,94 ± 0,02 mg AAE/g total antioxidant capacity [19]. Fatty acids composition inside *M. oleifera* seeds showed that it is belong to high-oleic acids category. Moringa oleifera is also a source of tocopherols at 98,82-134,42 mg/kg for tocopherol-α, 27,90-93,70 mg/kg for tocopherol-γ, and 48,00-71,16 mg/kg for tocopherol-δ [20].

In this study, ethanolic extract of *M. oleifera* seed showed a good performance as inhibitory agent for *E. coli* growth under laboratory condition. All of three group of treatment showed a significant difference of inhibitory zone diameter compared with control group (**Table 2**). Those result indicate that ethanolic extract of *M. oleifera* seed has bioactive compounds which play a role as antibacterial agent, especially for *E. coli*. Those bioactive compounds such as alkaloid, flavonoid, tannin, and saponin which has ability to inhibit the bacterial growth. Alkaloids are a nitrogen containing naturally occuring compounds that has an antibacterial activity due to their ability to intercalate with DNA of the microbes [21]. Alkaloid interrupt the composition of peptidoglican so that bacterial cell wall is not fully formed and leads to bacterial cell death. Flavonoid play a role as antibiotic, also tannin and saponin is a fenolic

compound which has antibacterial activity. Flavonoids have been reported have antimicrobial activity under laboratory condition through destruction of microbial membrane [22]. So, the bioactive compounds found at *M. oleifera* seeds promote its potency as antibacterial agent.

The widest inhibitory zone diameter was seen at T3, followed by T2 and T1 with 15,03 ± 0,55 mm; 11,00 ± 1,32 mm; and 7,03 ± 0,90 mm, respectively. Those result indicate that the higher concentration of ethanolic extract of *M. oleifera* seed has higher antibacterial activity for *E. coli* growth under laboratory condition. Both concentration of extract at T3 and T2 fall in the category as strong inhibitory activity for *E. coli*, yet concentration of extract at T1 is categorized as moderate (**Table 2**). The previous study indicate that *M. oleifera* has greater antibacterial activity against Gram positive bacteria, such as *S. aureus* and *E. faecalis* than Gram negative bacteria, such as *E. coli*, *Salmonella*, *P. aeruginosa*, *V. parahaemolyticus*, and *A. caviae* [23]. Nevertheless, in this study, ethanolic extract of *M. oleifera* seed still showed a greater inhibitory result to *E. coli* growth under laboratory condition. The ability of ethanolic extract of *M. oleifera* seeds to inhibit bacterial growth leads to its potency as antibacterial agent to overcome health issue about *E. coli* contamination among water, soil, food and other environmental properties. This antibacterial compounds found in *M. oleifera* enable society to utilize this plant as naturally safe antibiotics. Hopefully, the result of this study triggers other advance research to develop *M. oleifera* as natural product which can be used by society as local wisdom to overcome their environmental problem, especially in environment contamination of *E. coli*.

4. Conclusion

From this study, we conclude that ethanolic extract of *Moringa oleifera* seeds has the ability to inhibit *Escherichia coli* growth under laboratory condition. The widest inhibitory zone diameter is showed by 75% ethanolic extract of *M. oleifera* seeds, with strong inhibitory status. Even though the 50% extract is also showed strong inhibitory status, but its inhibitory zone diameter is tighter than 75% extract. The tightest inhibitory zone diameter is showed by 25% ethanolic extract of *M. oleifera* seeds, with moderate inhibitory status. Those result indicate that the higher concentration of ethanolic extract of *M. oleifera* seeds performs the wider inhibitory zone diameter which suggest a better inhibitory status to *E. coli* under laboratory condition.

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References

[1] Ercumen, A., Pickering, A. J., Kwong, L. H., Arnold, B. F., Parvez, S. M., Alam, M., Sen, D., Islam, S., Kullman, C., Chase, C., Ahmed, R., Unicomb, L., Luby, S. P., & Cloford, Jr., J. M. 2017. Animal feces contribute to domestic fecal contamination: Evidence from *E. coli* measured in water, hands, food, flies, and soil in Bangladesh. *Environmental Science & Technology, 51*, 8725-8734.

[2] Aijuka, M., Santiago, A. E., Girón, J. A., Nataro, J. P., & Buys, E. M. 2018. Enteroaggregative *Escherichia coli* is the predominant diarrheagenic *E. coli* pathotype among irrigation water and food saources in South Africa. *International Journal of Food Microbiology, 278*, 44-51.

[3] Leonard, A. F. C., Zhang, L., Balfour, A. J., Garside, R., Hawkey, P. M., Murray, A. K., Ukoumunne, O. C, & Gaze, W. H. 2018. Exposure to and colonisation by antibiotic-resistant *E. coli* in UK coastal water users: Environmental surveillance, exposure assessment, and epidemiological study (Beach Bum Survey). *Environment International, 114*, 326-333.

[4] Ng, C., Chen, H., Goh, S. G., Haller, L., Wu, Z., Charles, F. R., Trottet, A., & Gin, K. 2018. Microbial water quality and the detection of multidrug resistant *E. coli* and antibiotic resistance genes in aquaculture sites of Singapore. *Marine Pollution Bulletin, 135*, 475-480.

[5] Nowicki, S., deLaurent, Z. R., de Villiers, E. P., Githinji, G., & Charles, K. J. 2021. The utility of *Escherichia coli* as a contamination indicator for rural drinking water: Evidence from whole genome sequencing. *PloS ONE, 16*(1): e0245910. https:// doi.org/10.1371/journal.pone.0245910

[6] Navab-Daneshmand, T., Friedrich, M. N. D., Gächter, M., Montealegre, M. C., Mlambo, L. S., Nhiwatiwa, T., Mosler, H., & Julian, T. R. 2018. *Escherichia coli* contamination across multiple environmental compartments (soil, hands, drinking water, and handwashing water) in Urban Harare: Correlations and risk factors. *American Journal of Tropical Medicine and Hygiene, 98*(3), 803-813. https://doi.org/10.4269/ajtmh.17-0521

[7] Probert, W. S., Miller, G. M., & Ledin, K. E. 2017. Contaminated stream water as source for *Escherichia coli* O157 illness in children. *Emerging Infectious Diseases*, 23(7), 1216-1218.

[8] Luna-Guevara, J. J., Arenas-Hernandez, M. M. P., Martinez de la Peña, Silva, J. L., & Luna-Guevara, M. L. 2019. The role of pathogenic *E. coli* in fresh vegetables: Behavior, contamination factors, and preventive measures. *International Journal of Microbiology*, 2019, 1-10. https://doi.org/10.1155/2019/2894328

[9] Kholifah, Y. F., Dewi, E. R. S., & Widyastuti, D. A. 2019. Kemampuan daya hambat limbah kulit manggis (*Garcinia mangostana* L) sebagai antibakteri pada *Bacillus cereus* ATCC 10876. Prosiding Seminar Nasional Sains dan Entrepreneurship VI. ISBN 978-602-99975-3-8.

[10] Nurdyansyah, F. & Widyastuti, D. A. 2020. Comparison of antioxidant activity of ethanolic, methanolic, n-hexan, and aqueous extract of *Parkia speciosa* peel based on half-maximal inhibitory concentration through free radical inhibition. *Advance Sustainable Science, Engineering and Technology*, *2*(2), 0200207-01.

[11] Nurdyansyah, F., Widyastuti, D. A., & Mandasari, A. A. 2021. Ethanolic extract effect of *Parkia speciosa* peel to hepar function used cooking oil exposed *Rattus norvegicus*. Jurnal Ilmu Kefarmasian Indonesia, 19(1), 111-117.

[12] Katata-Seru, L., Moremedi, T, Aremu, O. S., & Bahadur, I. 2017. Green synthesis of iron nanoparticles using *Moringa oleifera* extracts and their applications: Removal of nitrate from water and antibacterial activity against *Escherichia coli. Journal of Molecular Liquids*, 2017. https://doi.org/10.1016/j.molliq.2017.11.093

[13] Pritchard, M., Craven, T., Mkandawire, T., Edmondson, A. S., & O'Neill, J. G. 2010. A comparison between *Moringa oleifera* and chemical coagulants in the purification of drinking water – An alternative sustainable solution for developing countries. *Physics and Chemistry of the Earth, 35*, 798-805.

[14] Walter, A., Samuel, W., Peter, A., & Joseph, O. 2011. Antibacterial activity of *Moringa oleifera* and *Moringa stenopetala* methanol and n-hexane seed extracts on bacteria implicated in water borne diseases. *African Journal of Microbiology Research*, *5*(2), 153-157. https://doi.org/10.5897/AJMR10.457

[15] Abalaka, M. E., Daniyan, S. Y., Oyeleke, S. B., & Adeyemo, S. O. 2012. The antibacterial evaluation of *Moringa oleifera* leaf extracts on selected bacterial pathogens. *Journal of Microbiology Research*, *2*(2), 1-4.

[16] Okuda, T., Baes, A. U., Nishijima, W., & Okada, M. 2001. Isolation and characterization of coagulant extracted from *Moringa oleifera* seed by salt solution. *Water Research*, *35*(2), 405-410.

[17] Widyastuti, D. A. & Rahayu, P. 2017. Antioxidant capacity comparison of ethanolic extract of soursop (*Annona muricata* Linn.) leaves and seeds as cancer prevention candidate. *Biology, Medicine, & Natural Product Chemistry*, *6*(1), 1-4.

[18] Gülçin, I., Küfrevioğlu, Ö, I., Oktay, M, Büyükokuroğlu, M. E. 2004. Antioxidant, antimicrobial, antiulcer and analgesic activities of nettle (*Urtica dioica* L.) Journal of Ethnopharmacology, 90(2-3), 205-215. https://doi.org/10.1016/j.jep.2003.09.028

[19] Ogbunugafor, H. A., Eneh, F. U., Ozumba, A. N., & Igwo-Ezikpe, M. N. 2011. Physico-chemical and antioxidant properties of *Moringa oleifera* seed oil. *Pakistan Journal of Nutrition*, *10*(5), 409-414.

[20] Anwar, F., Latif, S., Ashraf, M., & Gilani, A. H. 2007. *Moringa oleifera*: A food plant with multiple medicinal uses. *Phytotherapy Research, 21*, 17-25.
[21] Akinyeye, A. J., Solanke, E. O., & Adebiyi, I. O. 2014. Phytochemical and antimicrobial evaluation of leaf and seed of *Moringa oleifera* extract. *International Journal of Research in Medical and Health Sciences, 4*(6), 1-10.
[22] Okorondu, S. I., Akujobi, C. O., Okorondu, J. N., & Anyado-Nwadike, S. O. 2013. Antimicrobial activity of the leaf extracts of *Moringa oleifera* and *Jatropha curcas* on pathogenic bacteria. *International Journal of Biological and Chemical Sciences, 7*(1), 195-202.
[23] Peixoto, J. R. O., Silva, G. C., Costa, R. A., de Sousa Fontenelle, J. L., Vieira, G. H. F., Filho, A. A. F., & dos Fernandes Vieira, R. H. S. *In vitro* antibacterial effect of aqueous and ethanolic *Moringa* leaf extract. *Asian Pasific Journal of Tropical Medicine*, 4(3), 201-204. https://doi.org/10.1016/S1995-7645(11)60069-2

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