Physical characteristics of effervescent tablet probiotics in various concentration of tapioca coatings

D A Oktavia¹*, D L Ayudiarti¹, D Febrianti² and V Yanuar³

¹Research and Development Center for Marine and Fisheries Product Processing and Biotechnology, Jakarta
²Directorate of Fishing Port, Directorate General of Capture Fishing Port, Jakarta
³Antakusuma University, Pangkalan Bun, Central Kalimantan

*Corresponding author e-mail: deviambarwat@gmail.com

Abstract. RICA (Research Institute for Coastal Aquaculture) Maros in South Sulawesi has developed 5 probiotic preparations, namely RICA-1, RICA-2, RICA-3, RICA-4 and RICA-5 in liquid form to improve shrimp farming in ponds. In practice, the use of liquid probiotics has been very optimal but the distribution is constrained because of its liquid form. For this reason, microencapsulation of liquid probiotics is carried out to protect from the external environment and maintain the viability of probiotic cells in the encapsulated matrix. The purpose of this study was to determine the physical properties of probiotic effervescent tablets using tapioca coating with different concentration variants (10 and 20%) with four effervescent tablet formulas. The results showed that the pH of the probiotic effervescent tablet Formula 3 with a coating concentration of 10% tapioca had a neutral pH compared to all existing formulas. However, the pH for probiotic effervescent tablets produced by all formulas can still be applied to shrimp ponds. Formula 4 with 10% tapioca coating has a mean weight and hardness that is close to the standard as well as a disintegration time that meets the specified standard of tablet physical properties. Meanwhile, the tablet friability value was met by Formula 3 with a concentration of 10% tapioca coating. It can be concluded that the best formula that meets the standard physical properties of tablets is Formula 4 with 10% tapioca coating. The probiotic effervescent tablet with tapioca coating has a weakness in the hardness value which causes the average weight to be not uniform. These results indicate that tapioca coating is not suitable for use as a coating for probiotic effervescent tablets.

1. Introduction

White spot disease (white spot) in tiger shrimp in ponds is caused by White Spot Syndrome Virus (WSSV). This deadly disease usually attacks pet shrimp at the age of 1-2 months in ponds. If the attack rate is high it can cause crop failure. The shrimp disease that haunts pond farmers every year can now be prevented with probiotic bacteria. The use of RICA probiotic bacteria in tiger shrimp rearing has many advantages, including safety from various chemicals, does not accumulate in the food chain, a reproductive process that can reduce repeated use, target organisms rarely become resistant to probiotic agents compared to their resistance to chemicals or antibiotics and can be used
together (synergize) with other control methods [1]. The bacteria commonly used for probiotics in shrimp include *Bacillus* sp., *Bacillus subtilis*, *Lactobacillus* spp., *Brevibacillus* sp., *Pseudomonas* sp., *Pseudoalteromonas* sp., *Vibrio alginolyticus* and *Vibrio carcarie* [2].

Disease control strategies in aquaculture that are widely practiced and give good results are through biological control, one of which is the application of probiotics. This is done with the consideration that the use of probiotic bacteria has advantages such as the organisms used are safer than the use of chemicals, do not accumulate in the food chain, can reduce repeated use in reproduction, target organisms rarely become resistant to probiotic agents and can be used to treat probiotics, joint control, controlling pathogens in the host and environment, stimulating shrimp immunity and as an agent for improving water quality through its ability to reduce pollutants [3].

Several types of probiotics have been circulating in the market, both in liquid and powder form, but some of them have decreased in population due to the time used. Since it is packaged, it takes a long time to enter the trade system until it reaches the farmers. Therefore, the search for other probiotic bacteria from the area around the cultivation needs to be done so that they can become probiotic candidates that can grow and develop well. Probiotic isolates from locations close to the cultivation environment will be more adaptable, making it easier for them to grow and develop properly [4].

Importance of probiotic viability, namely beneficial microbial preparation of life. The number of living microbes must be sufficient to provide a positive effect on health and be able to colonize so that it can reach the amount needed for a certain time. To maintain bacterial viability, it is necessary to protect bacteria, one of them is the encapsulation method [5]. The coating materials used must be heat resistant, easy to press and dissolve in water. The raw materials used in the process of making effervescent tablets are sources of acid, carbonate materials, fillers and other additives [6].

The purpose of this study was to determine the physical properties of probiotic effervescent tablets using tapioca coating with different concentration variants (10 and 20%) with four effervescent tablet formulas.

Currently, various methods have been attempted to overcome/prevent the emergence of diseases in shrimp culture, including the use of probiotics. Probiotics is a term used for live microorganisms that can have a good or health effect on organism cultivators. Several types of bacteria which are known to function as probiotic bacteria are *Alteromonas* sp., *Brevibacillus*, *Carnobacterium* sp., *Bacillus subtilis* and so on [4].

Probiotics are types of bacteria that are added to the environment to improve environmental quality. There are two benefits what is expected from this bacterial application are; (1) increase the population of non-pathogenic bacteria, (2) as decomposers of materials organics into minerals and converts toxic compounds into non-toxic ones, such as toxic ammonia and nitrite compounds into free nitrogen compounds through the process of nitrification and denitrification. Appropriate application of probiotic bacteria can help reduce the content of organic matter in ponds and maintain the availability of nutrients from the decomposition of organic matter, so that plankton stability can be maintained and the content of gases harmful to shrimp decreases [7]. The use of probiotics can reduce the use of disinfectants, antiseptics and antibiotics so that shrimp are safe for consumption. Disease attacks do not only occur at the cultivation level but at the hatchery level [8]. The advantage of using probiotic bacteria is to prevent shrimp disease because it is safer than various chemicals; not accumulating in the food chain; the reproductive process that can reduce repeated use; rare target organisms that become resistant to probiotic agents compared to their resistance to chemicals or antibiotics; can be used together by means of existing protection [9].

Probiotic encapsulation technology is an exciting field of pharmaceutics that has emerged and developed rapidly in the past decade. Based on this technology, a wide range of microorganisms have been immobilized within semipermeable and biocompatible materials that facilitate the efficient delivery of the living cells [10]. Encapsulation is the process of forming a continuous coating around an inner matrix that is wholly contained within the capsule wall as a core of encapsulated material, while immobilization refers to the trapping of material within or throughout a matrix. Encapsulation
tends to stabilize cells, potentially enhancing their viability and stability during production, storage and handling.

According to the properties of the compound to be encapsulated and the purpose of encapsulation, the structural material of edible coatings is based on proteins (such as zein, soy, collagen and gelatin), polysaccharides (such as cellulose derivatives, starch, alginate and chitosan) and lipids (such as glycerol esters and waxes), which may be used alone or in combination. The functionality of these materials may vary, as each component offers different properties to the composite matrix. Indeed, the mechanical and barrier properties of these films not only depend on the compounds used in the polymer matrix, but also on their compatibility and on cohesion forces, including covalent bonds, ionic bonds, and H-bonding, between coating-forming polymer molecules. There are different types of encapsulation systems, such as spray drying, spray chilling, co-extrusion and liposomes. These techniques enclose liquid droplets or small particles of a sensitive substance within a continuous edible coating. Therefore, the encapsulation technique most used in edible coating is the spray drying [11]. During encapsulation of bioactive compounds (antioxidants, antimicrobials, probiotics and flavors) these are introduced into a matrix or wall system (edible coating) to prevent their loss; by creating a solid barrier between the additive and environmental conditions, so it is protected [12].

The effective wall materials for spray drying should have functional properties, including good emulsification, film forming, high solubility, low viscosity at high concentrations and low cost properties. Native tapioca starch had more rigid or tight crystalline structure and high viscosity as compared to modified tapioca starch and these could influence rate of drying [13]. Starch is a wall material that is widely used for microencapsulation purposes. Unmodified and modified starches are increasingly considered for microencapsulation of vitamins, essential oils, flavors, drugs, and microorganisms [14].

The probiotic preparations such as tablets, powders etc. may contain lower viable counts. Of the 15 feed supplements examined, viable probiotic counts varied greatly, with 3 products containing no Lactobacilli at all, although the supplements were supposed to contain L. acidophilus [15]. Effervescent tablets are one of the tablet dosage forms made by compressing the active ingredients with a mixture of organic acids, such as citric acid or tartaric acid and sodium bicarbonate [16]. Effervescent tablets are practical products because they can increase the absorption of the active substance compared to conventional formulas. In the form of effervescent tablets, the active substance is already in the form of particles so it does not take time to disintegrate and is quickly absorbed [17]. The effervescent tablet formula contains basic ingredients and some additives. Additives function as fillers, adhesives, crushing agents and lubricants. The additives used in the manufacture of effervescent tablets must be easily soluble so that they do not produce residues when dissolved [18, 16].

2. Material and methods

2.1 Preparation probiotic powder

Liquid probiotics are suspended in 10% and 20% tapioca in 50 mL of water. This suspension is incubated for 30 minutes at 37°C with a constant rotation to adapt the mixture, before drying with a spray dryer. Probiotic powder is ready to be used after coming out of the dryer (spray dryer). The temperature of the spray dryer inlet is 160°C and the outlet is 40°C [19, 20].

2.1.1 Mixing ingredients. Before tableting, the ingredients used are first mixed evenly at room RH 25%. The mixing process uses wet granulation which is separated between acidic ingredients, namely citric acid and alkaline, namely bicarbonate sodium.
2.1.2 Tablet forming. Tablet forming can be done by compression method [6]. Material that has been mixed with the specified formula is put into the mold, then compressed with a pressing force. Tablet printing uses a mini tablet press machine.

2.2 Physical properties of tablets [21, 22, 23].

2.2.1 Mean weight. A total of 10 tablets were weighed randomly using analytical scales (brand Mettler-TOLEDO) to determine their mean weight; a deviation of 5% is still acceptable.

2.2.2 Hardness. Hardness was measured using a hardness tester (brand Erweka, model TBH-30). The results obtained were averages of 10 tablets and expressed in Newton (kg). The recommended minimum value for hardness is 30 N. A good tablet generally has a hardness of not less than 4 kg [23].

2.2.3. Friability. This parameter is determined using a friabilimeter (brand Erweka, model TAR). A total of 10 tablets are set at a speed of 25 rpm for 4 minutes. The maximum reduction value of 1% is still accepted.

2.2.4 Disintegration time. The disintegration time of the six tablets was determined using a disintegration apparatus (brand Erweka, model ZT3) and distilled water at 37±2°C as a disintegration medium. Disintegration time limit for the effervescent tablet for 5 minutes is still accepted.

3. Result and Discussion

In order to be available on the market, tablets must undergo numerous studies and tests. Thus, pharmacopoeia determines the acceptable limits for the many quality criteria that the tablet formulations must possess to be approved. By meeting the established quality criteria, the maximum safety of the product is guaranteed [22]. Examination of the physical properties of tablet effervescent probiotic is done indoors with a relative humidity of 25% to avoid the influence of moisture because effervescent tablets are hygroscopic.

Mean weight test aims to ensure dose uniformity between tablets. Good weight uniformity must meet the criteria set out in the Indonesian Pharmacopoeia III edition [24].

Based on the requirements in the Indonesia Pharmacopoeia, there should be no tablets that deviate more than 5% and none of the tablets weighed more than 10% of their standard deviation weight for weights over 300 mg [24]. It can be seen from Figure 1 that there are probiotic effervescent tablets
with 20% tapioca coating in Formula 1 and Formula 3 with 10% coating that have a standard deviation value that exceeds 10% of the weight of the tablet. While the probiotic effervescent tablet Formula 2 with 10% tapioca coating, Formula 3 and Formula 4 with 20% tapioca coating have a standard deviation value exceeding 5% by weight of the tablet. It can be concluded there is only one of the probiotic effervescent tapioca tablets produced that have uniformity of weight that meets the requirements in the Indonesian Pharmacopoeia, namely Formula 4 with 10% tapioca coating.

In accordance with the results of the study, the granules with good flow properties will be easy to flow and easy to press when tableting, resulting in tablets with smaller weight variations [25].

Friability testing needs to be done because the tablet hardness is not an absolute parameter of tablet strength. The friability of the tablet describes the physical strength of the outside of the tablet which plays a role in resisting mechanical shock. Good tablets have a value of clarity (fragility) of no more than 1% [25].

Friability tablets will immediately break on the surface of the water, so the solubility is relatively faster. Brittle tablets usually have a shorter dissolution time. The high pressing force causes the density of the tablet to decrease, so that the penetration of liquid into the tablet structure becomes difficult. This greatly affects the solubility of tablets [26]. If the pressure received by the material at the time of tablet pressing is low, then the tablet's hardness is low and crumbles easily. If the pressing force used when printing tablets is small, the pressure received by the material will also be small so that the tablet hardness is lower or brittle.

As seen from Figure 2, effervescent probiotic tablet with 20% tapioca coating on Formula 1 and Formula 2 have a value of 0 which means that they meet the required effervescent tablet clarity requirements, so with Formula 3 on 10% tapioca coating. Effervescent tablets of probiotics Formula 1, Formula 2 and 4 with 10% tapioca coating and effervescent tablet probiotic with 20% tapioca coating on Formula 3 and 4 have friability above the specified standard, consequently these tablets break easily and quickly dissolve while touching the surface of the water. Fragile tablets will dissolve immediately and break on the surface of the water, so the solubility is relatively faster. In accordance with the results of research, fragile tablets usually have a faster solubility [26]. The high compressive force during pressing causes the tablet density to be small, so that fluid penetration into the tablet structure becomes difficult. This affects the dissolution time of the tablet.

![Friability of tapioca probiotic effervescent tablets in different concentrations](image)

**Figure 2.** Friability of tapioca probiotic effervescent tablets in different concentrations.

Tablets with high friability will easily become powder, so that it can cause dust at the production site and can cause variations in tablet weight. Tablet strength can be one of the categories for assessing the ability of tablet binders [18]. The high concentration of sodium bicarbonate can cause tablet solubility to be faster. The high concentration of sodium bicarbonate with its properties as ingredients fillers can affect the tablets hardness and friability while when the concentration of sodium
bicarbonate decreases then the solubility will be low, besides that the pH of the effervescent tablet will be low [27].

High fragility will affect the level of the active substance in the tablet. Friability is affected by rough tablet angles, lack of powder binding capacity, too much fine powder, improper use of materials, too dry print mass. From the evaluation of the resulting tablets in Formula 1 and Formula 2 with 20% coating concentration has a value of 0% and Formula 3 with 10% coating has a value of 0.31%, it can be said that only these three tapioca probiotic effervescent tablets meet the requirements. The requirement for good friability is that it should not be more than 1% [21].

The resulting effervescent tablets of probiotics did not meet the tablet hardness requirements of 4-8 kg [23], only one of the four formulas is close to the specified tablet hardness value, namely Formula 4 with a concentration of 10% tapioca coating which is seen in Figure 3. This hardness test aims to determine the ability of the tablet in packaging against mechanical pressure and impact. Hardness is influenced by pressure during tableting, the nature of the binding material and the right filler and lubricant [25].

![Figure 3. Hardness of tapioca probiotic effervescent tablets in different concentrations.](image)

Modified tapioca flour shows a lower moisture content than the original starch. This difference could be related to the grain structure and viscosity of the starch. Real tapioca flour is stiffer or tighter in crystalline structure and high viscosity (as previously mentioned), compared to modified tapioca flour and this can affect the drying speed [13]. The high water content affects the hardness of the resulting effervescent tablets. As seen in Figure 3, the probiotic effervescent tablets in Formula 1 and Formula 2 did not produce a tablet hardness that was close to the standard of 4 Kg.

Tablet hardness is influenced by several factors, including the pressure force used during pressing, the properties of the raw materials and the type of adhesive used. Tablet hardness is generally associated with the type and purpose of its use. In the manufacture of effervescent tablets, which are sometimes produced brittle so that they break easily or are too hard to dissolve, this phenomenon is probably due to the determination of the formula and the use of a pressing force that is not optimal. Fragile effervescent tablets may dissolve easily, but these tablets are not resistant to mechanical disturbances during distribution or storage [26].
Figure 4. Disintegration time of tapioca probiotic effervescent tablets in different concentrations.

It can be seen in Figure 4 that the disintegration time of probiotic effervescent tablets that meet the standards are tablets in Formula 1 with 20% tapioca coating, Formula 2 in all treatment concentrations (10 and 20% tapioca coating), Formula 3 with 20% tapioca coating and Formula 4 with 10% tapioca coating, while Formula 3 tablets with 10% tapioca coating and Formula 4 with 20% tapioca coating do not meet the standards physical properties of effervescent tablets is 5 minutes [22, 23]. Comparison of sodium bicarbonate with citric acid greatly affects the solubility of the tablet, the high fraction of sodium bicarbonate will cause faster solubility. Concentration of sodium bicarbonate (NaHCO₃) which has a high influence on tablet solubility. This matter occurs because sodium bicarbonate functions as a destroyer and when reacted with water (H₂O) will produce CO₂ gas [26]. The soluble time of the effervescent tablets produced is not used for human consumption, so it does not affect if applied to the aquaculture environment. Tartrate acid provides a longer disintegration time than citric acid even though it forms more CO₂ [25]. Solubility is the time it takes for an effervescent tablet to break and become suspended. Carbon dioxide gas functions as an indication that effervescent gas has dissolved. Perfect solubility is characterized by the cessation of CO₂ gas production in water [6].

Figure 5. pH of tapioca probiotic effervescent tablets in different concentrations.

The pH produced in the effervescent probiotic tablet dissolution has a neutral pH which is 7 seen in Figure 5. This meets the pH requirements in the aquatic environment is around 7.5-8.7 [28]. This condition is a characteristic of sodium bicarbonate which can increase the pH of water. These results
indicate that the pH range produced is neutral and can be accepted by pond shrimp that live in the range 6.5-8.5 [7].

4. Conclusion

The results showed that the pH of the probiotic effervescent tablet Formula 3 with a coating concentration of 10% tapioca had a neutral pH compared to all existing formulas. However, the pH for probiotic effervescent tablets produced by all formulas can still be applied to shrimp ponds. Formula 4 with 10% tapioca coating has a mean weight and hardness that is close to the standard as well as a disintegration time that meets the specified standard of tablet physical properties. Meanwhile, the tablet friability value was met by Formula 3 with a concentration of 10% tapioca coating. It can be concluded that the best formula that meets the standard physical properties of tablets is Formula 4 with 10% tapioca coating. The probiotic effervescent tablet with tapioca coating has a weakness in the hardness value which causes the average weight to be not uniform. These results indicate that tapioca coating is not suitable for use as a coating for probiotic effervescent tablets.

References

[1] Atjo AS 2013 Probiotik Tangkal White Spot di Tambak http: www.pusluh.kkp.go.id
[2] Muliani, Nurbaya and Atmomarsono M 2010 Penggunaan Probiotik pada Pemeliharaan Udang Windu (Penaeus monodon) dengan Dosis Pakan yang Berbeda Prosiding Forum Inovasi Teknologi Akuakultur pp 249-259
[3] Suwoyo H S and Mangampa M 2010 Aplikasi Probiotik dengan Konsentrasi Berbeda pada Pemeliharaan Udang Vanam (Litopenaeus vannamei) Prosiding Forum Inovasi Teknologi Akuakultur pp 239-247
[4] Tampangallo B R, Pakidi C S and Rantetondok A 2013 Sintasan Benih Udang Windu yang Dipelihara dengan Beberapa Jenis Probiotik RICA dan Resistensinya terhadap Bakteri Patogen V. harveyi Prosiding Forum Inovasi Teknologi Akuakultur pp 863-874
[5] Magfirah, Budji R G and Sartini 2016 Uji Viabilitas Isolat Probiotik Asal Saluran Pencernaan Itik Pedaging Anas domesticus yang Dienkapsulasi dengan Metode Spray Drying pp. 1-10 http://repository.unhas.ac.id/handle/123456789/12914
[6] Mohrle R, Attwood D and Banker C S 1989 Effect of Compression Force, Humidity, and Disintegrate Concentration on the Disintregreation and Dissolution of Directly Compressed Furosemide Tablets Using Croscarmellose Sodium as Disintegrate Tropical Journal of Pharmaceutical Research 2 (1) 285-286
[7] Purwanta W and Firdayati M 2002 Pengaruh Aplikasi Mikroba Probiotik pada Kualitas Kimiawi Perairan Tambak Udang Jurnal Teknik Lingkungan 3 (1) 61-65
[8] Muliani, Nurbaya and Madeali M 1 2011 Teknik Aplikasi Bakteri Probiotik pada Pemeliharaan Udang Windu (Penaeus monodon) di Laboratorium J. Riset Akuakultur 6 (1) 81-92
[9] Atmomarsono M, Muliani and Tampangallo B R 2010 Aplikasi Bakteri Probiotik untuk Peningkatan Sintasan dan Produksi Udang Windu di Tambak Prosiding Forum Inovasi Teknologi Akuakultur 269-278
[10] Nisha, Y R, Milind B J and Imran A K 2013 Probiotic Delivery Systems: Applications, Challenges and Prospective Int. Res. J. of Pharmacy 4 (4) 1-9
[11] Janjarasskul T and Krochta J 2010 Edible packaging materials Annu Rev Food Sci Technol. 1 415–448
[12] Quirós-Sauceda A E, Ayala-Zavala J F, Olivas G I, Guadalupe I Olivas and González-Aguilar G A 2014 Edible Coatings as Encapsulating Matrices for Bioactive Compounds: A Review J Food Sci Technol 51 (9) 1674–1685
[13] Loksuwan J 2007 Food Hydrocolloid 21 928-935
[14] Hoyos-Levya J D, Bello-Perez L A, Alvarez-Ramirez J and Garcia H S 2016 Food Review Int. pp 1-31
[15] Kailasapathy K 2002 Microencapsulation of Probiotic Bacteria: Technology and Potential Applications Curr. Issues Intest. Microbiol. 3 39-48
[16] Pribadi Y S, Sukatiningsih and Sari P 2014 Formulasi Tablet Effervescent Berbahan Baku Kulit Buah Naga Merah (Hylocereus polyrhizus) dan Buah Salam (Syzygium polyanthum [Wight.] Walp) Berkala Ilmiah Pertanian 1 (4) 86-89
[17] Lee C Y 2006 Physical Characterization and Drug Release Profiling for Hard Capsules Prepared with Hydroxypropylcellulose or Polyethylene Oxide www.pharm.org.tw/cjp/issue/58-1/J006.pdf
[18] Ansel H C, Robinson J R and Ericsson T 1989 Effect of Compressibility and Powder Flow Properties on Tablet Weight Variation in Drug Development Industrial Pharmacy Journal Pharmaceutical Science 77 (4) 214-217
[19] Oktavia D A, Ayudiarti D L and Febrianti D 2020 Physical Characteristics of Probiotic Effervescent Tablets with Various Concentration of Maltodextrin as Coating Materials E3S Web of Conferences 147 1-10 https://doi.org/10.1051/e3sconf/202014700001
[20] Parrot E L 1971 Pharmaceutical Technology Fundamental Pharmaceutics ed 3 (Burgess Publishing Company: Minneapolis) pp 64-66, 73-83.
[21] Nagashima A I, Pansiera P E, Baracat M M and Gomez R J H C 2013 Development of Effervescent Products, in Powder and Tablet Form, Supplemented with Probiotics Lactobacillus acidophilus and Saccharomyces boulardii Food Sci. and Technol 33 (4) 605-611
[22] Amalia N E, Issusilaningtyas E dan Indratmoko S 2017 Formulasi dan Uji Sifat Fisik Tablet Hisap Ekstrak Etanol Bunga Rosella Hibiscus sabdariffa Linn.) dan Daun Teh Hijau Camellia sinensis (Lamk.) Kuntze J. Pharmaceuticals 1(1) 29-34
[23] Directorate General of Drug and Food Control 1979 Farmakope Indonesia Edisi III Departemen Kesehatan Republik Indonesia Jakarta 6,7
[24] Ansar, Rahardjo B, Noor Z and Rochmadi 2009 Optimasi Teknik Pembuatan Tablet Effervescent Sari Buah dengan Response Surface Method J. Teknol. dan Industri Pangan XX (1) 25-31
[25] Fung KY and King NM 2003 Product-Centered Processing: Pharmaceutical Tablets and Capsules J. AIChE. 49 (5) 1193–1218
[26] Kailaku SI, Sumangat J and Hernani 2012 Formulasi Granul Effervescent Kaya Antioksidan dari Ekstrak Daun Gambir J. Pascapanen 9 (1) 27 – 34