EXPLORATION OF THE POTENTIAL OF MICROALGAE AS A FEED SUPPLEMENT TO IMPROVE DAIRY CALVES PRODUCTIVITY AND HEALTH

Novi Mayasari[1*]

[1]*Faculty of Animal Husbandry, University Padjadjaran, Jatinangor, Indonesia*

Abstract

For many dairy farmers, calf morbidity and mortality result in significant financial losses. Diarrhoea induced by intestinal bacterial infections is the leading cause of calf mortality worldwide. Antibiotics incorporated in milk replacer have traditionally been used as prophylactic therapies. However, as public awareness about antibiotic resistance has grown, so has consumer interest in alternative supplements. Microalgae is one of the marine resources with the potential to be employed as a phytoadditive. Proteins, carbohydrates, lipids, vitamins, minerals, and other organic components, as well as other metabolites suitable for animal feed, are all found in microalgae. Microalgae have a high protein content of 58-63 percent, 0.88-1.56 percent fat, 5.6-8 mg/g beta-carotene, 2.24-2.62 mg/g vitamin C, and Vitamin E is around 0.89-1.04 mg/g, high antioxidant compound it has the potential to be used as an alternative to antibiotic for livestock including dairy calves. Microalgae also contain omega-3, especially DHA (Docosahexaenoic acid) which has a positive effect on the immune system. The research on the use of microalgae as a feed supplement in dairy calves has to be improved. The review underlines the nutritional and physiological value of microalgae to animals, with particular emphasis on the antioxidant effect in dairy calves' immunity.

Keywords: Yeast, Fungi, Coffee Pulp Waste, Fiber Fraction, Fermentation

INTRODUCTION

Dairy calves are born without intrinsic immunity or the ability to operate as adult ruminants. They must overcome two primary obstacles: gaining immunity and initially feeding as a nonruminant while the rumen develops and functions. A calf relies on its dam's colostrum to gain immunity at first by absorbing antibodies, before eventually synthesizing its own antibodies[1, 2]. The majority of a calf's nourishment comes from its liquid food until it begins to take enough dry feed, which helps the rumen mature and allows it to be weaned off the liquid diet [1-3]. Not only the diet, weather, infectious agent exposure, and, most importantly, the calf's passive immunological status all have an impact on calf health [4, 5]. Neonatal calf mortality rates remain unacceptably high on dairy farms. In calves, diarrhoea is the most common cause of death. Infectious agents induce neonatal calf diarrhoea, which is a prevalent illness in bovine production and causes significant financial losses [6]. Antibiotics classified as "highest priority critically important," such as third-generation cephalosporins and fluoroquinolones, are frequently used to treat respiratory and gastrointestinal infections in calves [7]. Antibiotic has been used and added to the milk replacer to increase the inhibition of bacterial growth. Unintended zoonotic impact through resistance transfer, irrational use of antibiotic feed additives in the cattle industry has become a global concern [8]. Feed additives used in animals for an extended period of time may induce microorganisms to adapt to the antibiotics, resulting in resistance to antimicrobial drugs[9].

Herbal plant extracts or their secondary metabolites with antimicrobial capabilities may have similar benefits as antibiotic feed

*Corresponding author:
novi.mayasari@unpad.ac.id
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additives in inhibiting pathogenic bacteria development and improving animal health, growth, and productivity [10]. Previous studies showed that microalgae contain secondary metabolites and can be used as feed additive and feed supplements for animals including dairy calves.

Indonesia is a maritime country with a total area of around 7.9 million km^2 of the total area, 93,000 km^2 is the inter-island sea and based on international conventions, 6.2 million km^2 is the Exclusive Economic Zone. Biodiversity and marine resources, including non-fish marine resources, are abundantly available in Indonesia. This can be a very good potential, one of which is by utilizing non-fish marine resources for commercial added value. One of the non-fish marine resources with very good potential to be developed is microalgae.

Microalgae are plant-like microorganisms with cellular size, do not have roots, stems, or leaves that distinguish them from higher plants. Microalgae can live in fresh water, seawater, soil, and extreme environments. Around 200,000-800,000 species of microalgae are found widely on earth, but only about 35,000 species have been identified (Main Researcher Expert Research Centre for Biotechnology Indonesia). One of the advantages of microalgae is the ability to grow fast and do not spend a large area for production. Based on its composition, the advantages of microalgae include a very high protein content of up to 71% so that it is classified as a source of Single Cell Protein (SCP), carbohydrates up to 64%, fat up to 22%, and several functional compounds including omega-3 or omega 6 fatty acids, bio-pigments, antioxidants chlorophyll, -carotene, phycocyanin, lutein, zeaxanthin, and vitamins that are needed in the food and health supplement industry, cosmetics, nutraceuticals, animal feed, and organic agricultural fertilizers. Microalgae can also function as antioxidants, antibacterial, anti-tumor, anticancer, reversal agent, fungicide, herbicide, also contains growth hormone.

Secondary metabolites from plants are commonly thought to be anti-nutritional in calves and monogastric mammals. Nonetheless, a few studies have showed that when utilized at optimum doses, some of them can have a positive impact on the host's metabolism and performance[10]. Many studies on the performance-enhancing effects of plant-based antimicrobials for diverse livestock species (pigs, have been done. However, the study about the effect of microalgae as feed supplement for dairy calves is less known. The objective of this study is to explore the potential of microalgae as a feed supplement to improve dairy calves' productivity and health.

MATERIAL AND METHODS

This study used secondary data from published articles. Literature study was conducted by searching literature using electronic database of Google Scholar (www.scholar.google.com). The database was chosen because it has high coverage rates of journals. Scientific articles were all written in English and Bahasa Indonesia. The search terms were microalga, marine resources, additive and diet. The keywords were typed on the advanced search or keywords were type in between two quotation mark (“). The word AND was used to combine the search. The search has not limited the year of publication, place of publication, and publisher.

RESULTS AND DISCUSSION

1. Types of microalgae

The identified microalgae consist of 3 divisions (Chlorophyta, Chrysophyta and Cyanophyta), 16 families, 23 genera and 24 different species. The species are Botrydiopsis arhiza, Navicula sp., *Scenedesmus bijuga, Palmella miniata, Scenedesmus quadricauda*, Chlorococcum sp., Selenastrum gracile, Dactylothece confluens, *Spirogyra sp., Gyrosigma sp., Pluto caldarius, Kirchneriella obesa magma, Glesterocapesa. Pseudotetraspora gainii, Netrium digitus, Ourococcus bicaudatus, Westella botryoides, Chroococcus sp., Chlorella sp., Terpsinoe americana, Borzia trilocularis, Cymbella cistula* and *Nannochloris bacillaris.*

Among the microalgae that have been identified, some that have been isolated consist of 3 divisions, 8 families, 9 genera and 10 different species, namely *Navicula sp., Scenedesmus bijuga, Scenedesmus quadricauda, Chlorococcum sp., Dactylothece confluens, Pluto caldarius, Westella botryoides, Chroococcus sp., Chlorella sp.,* and *Nannochloris bacillari*s. Of these various species, the microalgae that have the potential to be used as animal feed are Spirullina sp. and Chlorella sp. because it is low in calories, rich in minerals, vitamins, protein, and low in fat. Spirullina has a fairly high nutritional content, including protein (60-70% by weight), vitamin B12, provitamin A (b-carotene), and minerals, and is easily digested by livestock. While Chlorella has a protein content of 57-58%, carbohydrates 12-26%, and lipids 2-22% so that this type of microalgae has the potential to be used as a protein source for livestock.

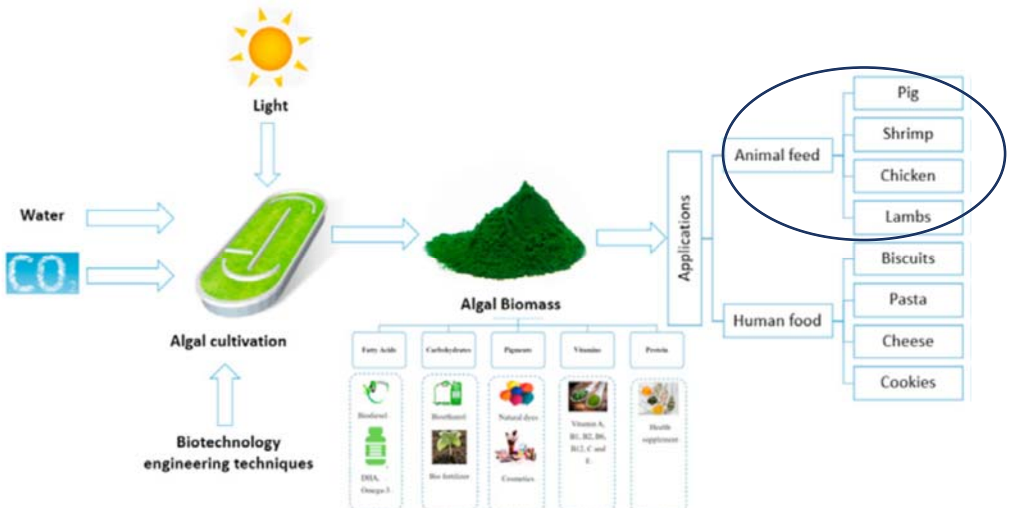

Fig. 1 Microalgae as an alternative feed source for livestock (adapted from Kusmayadi et al 2021)

Kusmayadi et al (2021) reported that microalgae not only provide an alternative source of protein, but they also provide the most vital nutrients, omega-3 and 6 long-chain polyunsaturated fatty acids, which can compete with those found in marine fish but with less chemical contamination and purity. Furthermore, microalgae pigments can operate as antioxidants as well as having a variety of other health-promoting effects. They can also be used as a natural colorant. Furthermore, adding algae to animal feed has numerous advantages, including improved growth and body weight, lower feed intake, improved immunological response and disease resistance, antibacterial and antiviral action, and enrichment.

More attention must be paid to algal cultivation in terms of environmental elements such as pH, light intensity, nutrient, CO2 supply, temperature value, mixing, and so on, in order to produce the optimal nutritional content of algae.[11]

2. Microalgae as a potential protein supplement in animal feeds

There are some consideration adopting plant as an alternative protein source for animal feed. Plant-based protein sources contain chemicals that obstruct nutrient digestion or impairing animal intestinal health. Trypsin inhibitor, lectin, glycinin, -conglycinin, raffinose family oligosaccharide, and -galactomannan are only a few of the antinutritional factors.

Chemical composition, g/kg DM of different algae, Costa et al, 2016 [12]

Algae or supplement	Organic Matter (%)	Crude Protein (%)	Crude Lipid (%	NDF	ADF	IVPD, %
Chlorella pyrenoidosa	936	580	136	4	0	16
Dunaliella salina	280	78	101	0	0	69
Nannochloropsis oculata	688	312	36	4	14	60
Nannochloropsis sp.	235	67	23	4	0	39
Schizochytrium sp.	904	120	198	0	3	33
Spirulina platensis	906	675	114	63	0	67
Chaetomorpha linum	584	195	34	166	104	53
Cladophora patentiramea	323	110	20	100	97	41
Enteromorpha sp.	607	303	46	170	90	48

Beyond biochemical composition, digestibility is one of the most important factors in determining the nutritional quality of novel feed ingredients. It is largely determined by solubility and the extent of chemical hydrolysis and enzymatic digestion in the gut, both of which are influenced by processing[13]

3. Application

Use of microalgae for Chicken

The addition of 10% of the microalgae species *Chlorella vulgaris* (CLV) from the diet showed an increase in the performance of broiler chickens [14]. CLV biomass grown in sewage is a rich source of protein and xanthophyll pigments, and levels of up to 20% in the diet are well tolerated by chicks [15]. Supplementation of 5-10% CLV in broiler rations is a suitable protein supplement, which has no detrimental effect on growth performance of broilers. The addition of microalgae extract as much as 2% can improve broiler performance and carcass yield [16]. Antibiotic growth promoter (AGP), virginiamycin (1%) and CLV-based supplements, including DCLP (Dried CLV Powder), CGF (CLV Growth Factor), and FLC (Fresh Liquid CLV) (1%), in broilers showed that supplementation CLV biomass feed is a viable alternative to AGP which can improve broiler chick performance (Kang et al., 2013). The addition of microalgae type Aurantiochytrium limacinum about 2% can enrich DHA in breast meat up to 80 mg DHA/100 g and thigh meat up to 104 mg DHA/100 g (Colm et al., 2018). [16]. From the results of these studies, it can be assumed that the addition of microalgae to the diet can affect the performance and carcass of broiler chickens.

Use of microalgae for Dairy Cows

The use of microalgae in dairy cow experiments has yielded favourable results with a direct impact on productivity[17]. Cows given dietary Spirulina exhibited a 21 percent increase in milk output, according to Kulpys et al. (2009)[18]. Furthermore, cows getting Spirulina had higher milk fat (between 17.6 percent and 25.0 percent), milk protein (up by 9.7 percent), and lactose (up by 11.7 percent) than cows receiving no Spirulina [19]. When cows were given Spirulina, the saturated fatty acid content of their milk reduced while monounsaturated fatty acids and polyunsaturated fatty acids (PUFAs) rose [20]. However, other study showed microalgae gave negative impact on milk yield and quality[21]. To avoid feed intake reductions and a worsening in milk yield and quality, great attention should be paid to the amount of algae supplemented and rumen protected forms should be examined. More research is needed to determine the best species/feed to use and the effects of long-term supplementation[21].

Lipid-extracted biomass (LEB) from freshwater microalgae reduced methane production by nearly half (P 0.001) to 0.9–1.2 mol, implying that feeding microalgae to ruminants could reduce enteric methane emissions by about half (P 0.001)[22]. Low digestion associated with inflexible cell walls of some microalgae and lower feed intake associated with poor palatability of microalgae-supplemented diets appear to be the main limitations.[22]. Furthermore, given the effects of diverse growing conditions on microalgae compositions and several factors that have still to be resolved, it is still too early to precisely characterize future dairy uses.

The impacts of microalgae on animal metabolic condition and welfare, as well as the existence of anti-nutritional agents in various species and the effects of long-term supplementation, should be explained. Furthermore, the quality and organoleptic features of dairy products from microalgae-fed cows should be investigated further.

Use of microalgae for Dairy Calves

Inclusion 6 g of Schizochytrium spp microalgae in the starter diet boosted starter intake and lowered oxidative responses regardless of supplementation duration. Moreover, microalgae supplementation should be limited to the last 15 days of suckling [23]. Microalgae supplementation could be a useful feed addition for suckling calves, but more research is needed to see how it affects pre-ruminant performance and health. Despite its well-documented benefits, the use of microalgae in ruminant diets is restricted in some circumstances due to its high cost[15].

CONCLUSION

Microalgae are a viable new feed resource for future animal production requirements. Many animal species' productivity, health, and product quality have all improved as a result of incorporating dietary micro algae in their feed diets. Many of the findings, however, contradict each other, resulting in an inconsistent trend in the usage of micro algae as an animal feed. As a result, more investigation into the potential of micro algae in ruminant especially in dairy calves is needed. Furthermore, research into micro algae active components and associated biological pathways would contribute to expanding our understanding, scope, and implications in sustainable animal production.

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