EVALUATION OF POTENTIAL YEAST AND FUNGI TO IMPROVE QUALITY OF COFFEE PULP AS FEED SOURCES FOR ANIMAL

Novi Mayasari[1*]

[1]Faculty of Animal Husbandry, UniversityPadjadjaran, Jatinangor, Indonesia

Abstract

This study evaluated the potential yeast and fungi to enhance quality of fermentation coffee pulp as a fiber source in diet of livestock. There were different yeast and fungi has been used on fermentation coffee pulp such as Aspergillus niger, Trichoderma viride, Rhizopusoryzae, Pleoratusostreatus, and Saccaromyces cerevisiae. It is known from several existing data that the treatment of the fermentation will influence the quality of fermentation. Different doses, single or multi culture of fungi and duration of fermentations affected the quality of coffee pulp fermentation. Type of coffee such as Arabica and Robusta coffee also affected fiber fraction of fermentation coffee pulp. The results showed that there were variations on fiber fraction such as lignin, cellulose, hemicellulose and tannin with different treatment of yeast or fungi fermentation. However, the variance of those fiber fraction seems similar after fermentation processes. Lignin and tannin were decreased by the fermentation. Meanwhile, hemicellulose and cellulose were increased after fermentation. Other benefits of fungi or yeast fermentation of coffee pulp increased protein content and reduced caffeine levels. Moreover, the supplementation of fermentation of coffee pulp did not give any negative effect on rumen pH, volatile fatty acid, NH3, and digestibility. In conclusion, the yeast and fungi had big advantages to improve the quality of coffee pulp waste especially on fiber and protein content in the diet of animals.

Key words: Yeast, Fungi, Coffee Pulp Waste, Fiber Fraction, Fermentation

INTRODUCTION

Coffee is a strategic product with massive content business volume world-wide. Demand for this agriculture product is enormous, and it produced sustainably. The output quantity has risen by 200 percent since 1950. The growth will continue as the world population continues to rise and demand will then also increase. Coffee pulp is the leftover material after coffee beans. Wet-process coffee grinding has been eliminated from the berries. The coffee pulp makes up 40–42 per cent of the coffee fruit total weight. Coffee pulp is used as a fertilizer and fuel source in the form of direct combustion at several locations around the world. Moreover, coffee pulp known as fiber source for animal feed[1].The significant amounts are produced at the showing disposal and environmental pressure on the manufacturing site. Coffee pulp therefore considered a source of dangerous pollution problems due to shortages of disposal technologies that end up in polluting rivers, creating odours and encouraging fly-spreading[2].

Regarding coffee pulp as feed source, coffee pulp contains several antiphysiological factors limit the use of coffee pulp in ruminant and monogastric feeding. The coffee pulp contains some quantity of caffeine and tannins which makes it toxic in nature resulting in the problem of disposal and harmful to animal welfare and detrimental on absorption of nutrients [3]. Among these is essential the properties of its lignocellulosic fraction. The condensed tannins comprise a group of oligomers and polyhydroxy-flavan-3-ol polymers bound between the flavanol subunits by the carbon-carbon bond. Condensed tannins have physiological implications for the formation with protein, carbohydrate and

[*]Corresponding author: novi.mayasari@unpad.ac.id
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mineral complexes and their impact on high concentrations of oxidants; they strongly bind to amino acid-rich proteins. Caffeine is a methylxanthine with bitter characteristics. Caffeine stimulates the central nervous system as an adenosine receptor antagonist. Caffeine increases the thirst of the animal, the urinary evacuation, and nitrogen excretion [4].

However, the coffee pulp is characterized by its high nutritional value with a high content of proteins, carbohydrates, and minerals. To improve the use of coffee pulp (Arabica or Robusta) to animal feed, caffeine and tannins were eliminated through the use of fungi fermentation[5]. Several studies have been carried out to enhance quality of fermentation coffee pulp using yeast or fungi. There is a broad variety of microorganisms which can generate cellulose such as aerobic and anaerobic bacteria, anaerobic fungi, soft red mushrooms, white red mushrooms and dark red mushrooms. The majority of the fungi will generate a complete system of cellulose compared to bacteria [6]. Previous study evaluated twenty-six white rot fungi were grown under strong substratum conditions, using coffee pulp previously ensiled and pressed without adding additional nitrogen sources[7]. This study showed there were only few fungi might be enhanced the fermentation of coffee pulp. Other studies suggested that factors such as pH, temperature and inoculum size are important parameters in the fermentation with fungi to achieve the coffee pulp quality. The objective of this study were to evaluated the potential yeast and fungi to enhance quality of fermentation coffee pulp as a fiber source in diet of livestock

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 coffee pulp, fermentation, fungi, yeast, 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

It’s known that coffee pulp have high nutritional values and some toxin components. Robusta and Arabica have different content (Table 1). Dry or wet processing on coffee may result in differ nutritional values on coffee pulp.

Table 1 Proximal composition of coffee pulp (coffee arabica from Londono-Hernandez et al. (2014) and coffee robusta (present study))

Nutrients	Arabica Concentration (%)	Robusta Concentration (%)
Protein (% m/m)	13.40	6.11
Fiber (%m/m)	16.23	18.69
Hemicellulose (% m/m)	28.66	NA
Cellulose (% m/m)	32.56	NA
Lignin (% m/m)	26.40	52.59
Caffeine (%)	NA	1.36
Tannins (%)	NA	2.47

NA : information is not available

Coffee husks and pulp have been reported to be used to feed farm animals like ruminants, pigs, chickens, and rabbits. Ambiguously,the high lignin content(≈25-50%), tannins and caffeine is considered as a limiting factor for its application[1].

It is known that solid-state fermentation of coffee pulp with fungi with certain time of incubation along with addition of extraction of pectinase may improve coffee pulp quality.

Strain of fungi resulted on varies fiber fraction coffee pulp pretreatments on fiber fraction. A previous study showed that *Trametes versicolor* was a very fast grower and showed the highest rates of degradation of holocellulose and lignin.

Other study showed that *Pleoratusostreatus* was the best fungi to

eliminate tannins, lignin and caffeine [8]. Most fungi narrowly favored hemicellulose over cellulose and more than 80 per cent of the initial hemicellulose degraded at least two.

Several studies reported potential fungal strain to enhance the production of cellulose, reduce caffeine content/decaffeination and eliminate tannins. Those fungal strain are *Lentinusedodes, Phanerochaetechrysosporium, Fomitopsissp, Pleurotussajor-caj, Leifsonia sp, Fusarium solani, Pleoratusostreatus, Aspergillus nigeretc.*Patra (2007) reported that the most potential fungal strain, which could improve quality of coffee pulp, enhance cellulose production and biotransform caffeine to theophylline, was characterized as *Penicilliumcitrinum*.

Other study evaluated seven strain such as *Bacillus cereus, Bacillus megaterium, Bacillus subtilis, Candida parapsilosis, Pichia caribbica, Pichia guilliermondii and Saccharomyces cerevisiae.*

Environment condition such as pH, temperature and moisture affected the fungi fermentation on coffee pulp. Each strain have different optimum environment condition. Several studies reported optimum pH, moisture, temperature and size of inoculum (Tables 2-5).

Table 2 Optimum pH of fungi to enhance fermentation coffee pulp quality

Reference	Strain	pH
Ibrahim, et al. (2016)[9]	*Leifsonia sp*	6.5
Nanjundaiah, et al. (2016)[10]	*Fusarium solani*	5.8
Lakskshmi and Das (2013)[11]	*Tricosporonasahii*	6.5
Patra (2007)[12]	*Penicilliumcitrinum*	5-6
Penazola, et al. (1985)[13]	*Aspergillus niger*	3.5

pH plays a crucial role during the growth and metabolism of an organism. Low moisture (low water availability) can limit the growth and metabolism of the microorganism. The pH, humidity and fermentation time to reduce the tannin content of the coffee pulp and the tannase enzyme output. Inoculum size is also important during fermentation, it must be high enough to allow propagation and predominance of the strain.

Table 3 Optimum temperature of fungi to enhance fermentation coffee pulp quality

Reference	Strain	Temperature
Ibrahim, et al. (2016) [9]	*Leifsonia sp*	27°C
Nanjundaiah, et al. (2016) [10]	*Fusarium solani*	24°C
Lakskshmi and Das (2013) [11]	*Tricosporonasahii*	28°C
Penazola, et al. (1985)[13]	*Aspergillus niger*	28°C
Present study	*Pleoratusostreatus*	35°C

Table 4 Optimum moisture of fungi to enhance fermentation coffee pulp quality

Reference	Strain	Moisture
Brand, et al. (2001) [14]	*Aspergillus niger*	55%
Brand, et al. (2000) [15]	*Ryzobiumoryzae*	50%
Penazola, et al. (1985)[13]	*Aspergillus niger*	80%
Present study	*Pleoratusostreatus*	60%

Table 5. Optimum size of inoculum of fungi to enhance fermentation coffee pulp quality

Reference	Strain	Size of inoculum
Nanjundaiah, et al. (2016) [10]	*Fusarium solani*	4.8×10^5
Lakskshmi and Das (2013) [11]	*Tricosporonasahii*	High inoculum is better

Figure 1 shows concentration of NH3-N and VFA production in ruminant fed diet supplemented fermented coffee pulp fermented by *Pleoratusostreatus*in goat, dairy cows/cattle and cattle rumen fluid (in vitro) from three studies. No statistically significant differences were observed in ruminal VFA and NH3-N ($P>0.05$) in two studies [8] and present study. They suggested that coffee pulp was an excellent substrate for mushroom cultivation, especially *P. ostreatus.*

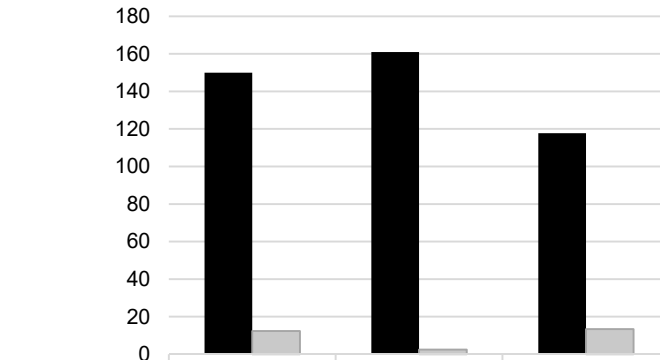

Figure 1. Concentration of volatile fatty acid and N-ammonia of Goat, Dairy Cattle (Badarina et al. (2013 and 2014)[8, 16]and Beef Cattle (present study) fed diet contain fermented coffee pulp by *P. ostreatus.*

The increasing protein and cellulose contents and the decreasing lignin and anti-nutritional substances (tannin and caffeine) in the coffee pulp after fermentation by *P. ostreatus* can increase its value as by-product in ruminant nutrition.

CONCLUSION

In conclusion,the yeast and fungi had great advantages in improving the quality of coffee pulp waste, especially on the fiber and protein content in animal diets. It is important to search for the suitable combination of fungal strain and lignocellulosic substrate for optimal cellulose production, elimination of tannins and caffeine during coffee pulp fermentation.The use of fermented coffee pulp in diets of animals did not give any negative effect on rumen pH, volatile fatty acid, NH3, and digestibility.

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