1. INTRODUCTION

Background

Milk production in Indonesia is increasing yearly, however, it has not fulfilled milk demand. In 2011, milk production was 926 $10^3$ tons, while the total demand of milk and milk product was 3,903 $10^3$ tons (DGLAH 2011). The lack of this milk demand would be imported for about 76.27% a year; with an international milk price of $400/ton, it would cost around $1,190,800,000/yr. On the other hand, with 17,483 $10^3$ population of goat in 2011, supposed 0.5% out of them was dairy goat and 30% of them was in lactation with 0.5 kg/d milk production, in one lactation period would be producing milk about 1,967 tons. There might be a potential alternative of milk production as much as 0.05%/yr to supply national milk demand. This assumption might be too low compared to data released by FAO that was about 1.56% goat milk contributed by Indonesia to the world goat milk (Thiruvenkadan 2012). This huge gap of milk consumption and milk production should be narrowed. At the same time, the quality of the milk needs to be improved as well. For these purposes there has to be nutrition manipulation that could be applied to the dairy ruminants, such as dairy goat.

In terms of fatty acid (short, medium-chain, saturated branched, mono-polyunsaturated, cis-trans conjugated) contents in animal product, including milk, have been receiving a lot of attention concerning of human health (Chilliard et al. 2003). Therefore, it needs efforts in improving rumen kinetics relating to nutrients of the feed provided, especially in improving the polyunsaturated fat, PUFA. This could be achieved by applying diet rich in PUFA (such as roasted corn grain, roasted soybean meal, and corn oil) supplemented with temulawak (Curcuma xanthorrhiza Roxb) and yeast.

Curcuma xanthorrhiza Roxb, within its root, contains some bioactives such as curcuminoids (3% of dry matter) consisting of curcumin (C), demethoxycurcumin, and bisdemethoxycurcumin (Rukayadi et al. 2008); and xanthorrhizol (33.2% of rhizome oil) reported by Sirat et al. (2008). Curcumin has molecular weight of $C_{21}H_{20}O_6$ that would decrease due to the changes of poliphenol weight during radiation process of curcuma powder and curcuma simplicia. This condition resulted in degradation of covalent bond that changed to free phenol becoming highly active in antioxidant compared to that of in curcumin tablet and fresh curcuma (Nurlidar and Chosdu 2008). Bioactive of curcumin also functions as antibiofilm (Rukayadi et al. 2008), antimicrobial, anti-inflammation, anticancer (apoptosis, antiangiogenesis), detoxification, neuro protection, and antiaging (Hwang 2008); elevates bile production, lessens tissue inflammation and plasma LDL (low density lipoprotein) in rabbit (Wientarsih and Meulen 2008). It was also reported that in early identification, curcumin and xanthorrhizol worked very strong as antibacterial and effectively slow down the growth of Staphylococcus aureus, Salmonella paratyphi, Trichophyton gypseum, and Mycobacterium tuberculosis (Benson 2012).

Curcumin interacts with adiposity pancreas cells, heart cells, macrophage, and muscle in suppressing proinflammatory transcription factors (Aggarwal 2010). As anti inflammation and anti pathogen, curcumin is expected to decrease inflammation in mammary gland causing mastitis. The indicators of this
are decreasing SCC (somatic cell count), *Staph. aureus*, and *E. coli* contents in milk.

In organic (less use of antibiotic synthetic) dairy farm, it was found decreasing CNS (coagulate negative staphylococci) and environment *Streptococcus* sp in milk sample (Suriyasataporn 2010). Normal SCC level of dairy cow milk was less than 1 x 10^5 cfu/ml; while the infected cow was 1 x 10^6 cfu/ml (BytyQi et al. 2010). It has been reported also that SCC (consisting of 75% leucocytes: neutrophils, macrophages, lymphocytes, erythrocytes, monocytes; and 25% epithelial cells) in infected dairy cows were facing potential loss of milk production for up to 1200 kg/lactation with SCC of 2.2 - 4.5 x 10^6 cells/ml (Sharma et al. 2011). There was correlation between high level of SCC and mastitis associated with decreasing lactose, α-lactalbumin, and milk fat (Harmon 1994).

Combination of polyherbal in low level (125 mg/kg body weight) produced milk optimally in dairy goat (Mirzaei and Prasad 2011). Curcuma, including *C. xanthorrhiza* Roxb, also contains bioactive steroid that served as lactagogue, conserving the continuity of cell differentiation of epithel cells in normal tissue, mucose secretion, alveolus proliferation, and ductul growth in mammary gland. Hormones relating to this process such as prolactin is the most secreted hormone right before partus (Larson 1985). Concentration of prolactin in dairy goat blood decreased from 18.55 ng/ml in 15 days of lactation to 5.88 ng/ml in 150 days of lactation (Singh and Ludri 2002). Therefore, curcuma besides maintaining lactation, also containing other secondary compound, such as tannin and saponin that function in microbial rumen activity.

Ruminal kinetics are expressed by microbial rumen activity in digesting fiber that its dynamics were affected by protozoa functioning as predator for bacteria (Gutierrez 2007). Saponin (triterpenoid and steroid saponin) generated from any materials were identified detrimental toward protozoa (antiprotozoa) and as defaunating agent in rumen with the effect of detergent foaming on the surface of cell membrane (Francis et al. 2002). Saponin generated from lerak (*Sapindus rarak*) extract of 0.8 mg/ml rumen liquor decreased protozoa population and affected composition and total bacteria population after 24 hours in vitro fermentation. Population of *F. succinogenes* bacteria was dropped with increasing concentrate; whereas *P. ruminicola* increased markedly with increasing *Sapindus*. Decreasing protozoa was associated with decreasing activity of methanogen; modifying H2 to be propionate supported by bacteria with certain amount of population and appropriate type as well as abundant amount of substrate (Sugiarti et al. 2011).

Beside saponin, tannin is an effective poliphenol in decreasing methan (CH4) gas production that was produced about 10% out of energy, *in vitro* or *in vivo*. The efficacy of tannin depends on type of carrier materials, easily hydrolyzed (easily accumulated, toxic) or condensed (bound, safe). Tannin from chestnut was the most reasonable in reducing CH4 gas per digested organic matter with the lowest C2/C3 ratio (Jayanegara et al. 2008). Methane gas is affected during fermentation process of fat source of diet and metabolized it through lipid hydrolysis process with end results of triglyceride, free fatty acid, glycerol, then continued in β- oxidation to yield acetate and H2, as the precursors of methane gas production (Sage et al. 2008).
Lipid supplementation produced fatty acid, including CLA (conjugated linoleic acid) based on its source; high in cooking oil and fresh grass, but, low in unprotected grain oil (Chilliard et al. 2003). Free fatty acid and CLA in the rumen will be biohydrogenized (hydrolyzed by bacteria with addition of 2 ion $H^+$ to be saturated; in conversely, it should be bypassed then biosynthesized as unsaturated fat in milk). Eventually, it is transported into mammary gland (as in precursor), changed from linolenic acid (C18:3 cis 9, cis 12, cis 15) in several steps to become stearate (C18:0), then ultimately converted into oleate in mammary gland. This process is optimazed by SCD (steoroyl-CoA desaturase) enzyme. Fatty acid content of milk of goat fed sunflower and soy bean oil was lowered in saturated fat and atherogenicity index (1.21 - 1.71), but increased in CLA compared to control. This suggested that unsaturated fatty acid in blood vessel was going up that made this index down as expected (Chilliard et al. 2003).

Yeast, mostly mentioned as *Saccharomyces cerevisae* in any forms, dried or liquid, is widely used as rumen enhancer or fermenting feed supplement with variable effects on dry matter and organic matter digestibility, ruminal microbes, and ruminal fermentation activity (pH rumen, VFA, lactate, milk production, and fatty acid) as described by Desnoyers et al. (2009). Lynch and Martin (2002) reported that yeast, both in culture and cells showed no different activities; however with high dose (0.73 g/l) produced lower CH4 and C2/C3 in *in vitro* fermentation of diet containing Bermuda grass. Viability of yeast cell in dry form was decreasing (from $9.88 \times 10^{10}$ cfu/g to $5.43 \times 10^{10}$ cfu/g) after 3 months of storage in 40°C (Sullivan and Bradford 2011). Supplementation of RumiSacc, commercial yeast, was not significantly different from control in affecting BUN (blood urea nitrogen), cholesterol, triglyceride, and glucose of dairy cow (Yalcin et al. 2011).

Synergy of temulawak (curcuma), yeast, and PUFA- concentrate has been gradually conducted in lactating ruminants. Milk production of lactating Bali cow could increase 6.6- 9.3 times higher with 5% pasta of fermented cassava and temulawak (*C. xanthorrhiza* Roxb) liquid, reported by (Sulistyowati 1999); milk yield has doubled with Tabut (abbreviation for fermented cassava and curcuma) block (300g) in lactating Bali cows (Sulistyowati et al. 2001); in FH dairy cow with Tabut block, its milk production increased with increasing amount (0- 450g) of the block following this model: $Y: 6.66 + 0.05 x$, $r: 0.90$ (Sulistyowati and Erwanto 2009). Microbial population of Tabut block decreased with increasing curcuma (15-25%) during storage of 3- 12 weeks (Sulistyowati et al. 2008b), while 15% curcuma level was optimal for milk production (Sulistyowati et al. 2008a) in FH dairy cows; 2%yeast supplementation in FH dairy cows produced the highest milk yield (Sulistyowati et al. 2010b); concentrate containing 10.5% C. *xanthorrhiza* Roxb was optimal for milk production in FH dairy cows (Sulistyowati et al. 2010a); PUFA- concentrate containing 4.5% roasted ground corn produced the highest milk production with lower milk fat with increased PUFA and ratio of n6/n3 was about 2.14 in milk of dairy cow (Sulistyowati et al. 2010a) with high TDN (Sulistyowati et al. 2010b); curcuma concentrate in lactating dairy cow (Sulistyowati et al. 2011). Meanwhile, milk production of dairy goat supplemented with 3g/d of yeast was optimal (Sulistyowati and Mega 2002); whereas, dairy goat fed pasta of fermented cassava and curcuma liquid
could increase milk production for 0.1 kg/d with significant reduction in milk fat to 2.09% (Sulistyowati 2009).

However, along with these researches, there has not been studied on ruminal activity, blood metabolites, milk fatty acid quality and milk production, especially in dairy goat, moreover during late lactation. Therefore, three experiments had been conducted (nutrient quality of stored PUFA-concentrate, \textit{in vitro} ruminal fermentation, and \textit{in vivo} application of PUFA-diet supplemented with yeast and \textit{C. xanthorrhiza} Roxb) in late lactating dairy goat.

\section*{Problems}

Based on above description, it has been analyzed several problems that need to be improved:

1. Milk production of dairy goat was very low compared to its actual capacity.
2. Milk quality, especially milk fatty acid was high in saturated fat.
3. Ruminal fermentation needs to be manipulated with nutrient originated from PUFA –diet supplemented with curcuma and yeast.

\section*{Research Purposes}

Based on the identified problems, three experiments were designed to meet those three purposes:

1. To evaluate nutritional quality of PUFA- concentrate containing roasted ground corn, roasted soybean meal, corn oil supplemented with curcuma and yeast stored in 2, 4, and 6 weeks.
2. To analyze performance of PUFA- diet supplemented with curcuma and yeast in \textit{in vitro} ruminal fermentation.
3. To evaluate PUFA- diet added with Asifit tablet (a commercial tablet for women in lactation), curcuma and yeast on nutrient digestibility, blood metabolites, mammary health, production and fatty acid quality of milk of late lactating dairy goat.

\section*{Research Outcomes}

Out of each experiment, there would be a result that could be applied, those are:

1. One PUFA – concentrate formula that is durable in nutritional quality during the 2-6 weeks of storage.
2. One PUFA- diet formula that is optimal in \textit{in vitro} ruminal fermentation that is optimal metabolically.
3. One formula of PUFA- diet that is optimal for mammary health, production and fatty acid quality of milk of late lactating dairy goat.

\section*{Research Hypothesis}

1. Curcumin and tannin within curcuma are able to protect nutrients of PUFA- concentrate stored for up to 6 weeks.
2. Curcumin, tannin, yeast (*Saccharomyces cerevisae*), and PUFA sources (roasted ground corn, roasted soybean meal, and corn oil) in PUFA-diet were able to reduce unwanted microbes, such as protozoa in such a way that would improve metabolic rumen in biohydrogenation process.

3. Curcumin, tannin, yeast (*Saccharomyces cerevisae*), and PUFA sources (roasted ground corn, roasted soybean meal, and corn oil) in PUFA-diet were able to improve metabolic rumen in biohydrogenation process that eventually will improve mammary health, production and fatty acid quality of milk of late lactating dairy goat.