ENHANCING THE EFFICIENCY TO UTILISE OF INULIN FROM PLANTS AS A PREBIOTICS IN GOAT KID DIETS

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การเพิ่มประสิทธิภาพการใช้ประโยชน์อินนูลินจากพืชเพื่อใช้เป็นพรีไบโอติกในอาหารลูกแพะ

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาปรัชญาดุษฎีบัณฑิต
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Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

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วัตถุประสงค์ของงานวิจัยนี้ คือศึกษาการใช้อินนูลินจากพืชเปรียบเทียบกับอินนูลินทางการค้าในการเพิ่มประสิทธิภาพการผลิต การลดปริมาณแบคทีเรียก่อโรค ลักษณะทางโลหิตวิทยา และประสิทธิภาพการย่อยอาหารได้ในลูกแพะก่อนหย่านม

การทดลองที่ 1 ทำการศึกษาผลของระดับอินนูลินในนมต่อประสิทธิภาพการผลิตของลูกแพะก่อนหย่านม จากการศึกษาในลูกแพะนมแยกเพศ จำนวน 20 ตัว (Thai native-Anglo-nubian) วางแผนการทดลองแบบสุ่มในบล็อกสมบูรณ์ โดยการทดลองแบ่งเป็น 5 กลุ่มทดลอง ได้แก่ กลุ่มที่ 1 กลุ่มควบคุม กลุ่มที่ 2 การเสริมอินนูลินจากแก่นตะวันที่ระดับ 2% กลุ่มที่ 3 การเสริมอินนูลินจากแก่นตะวันที่ระดับ 4% กลุ่มที่ 4 การเสริมอินนูลินทางการค้าที่ระดับ 2% และกลุ่มที่ 5 การเสริมอินนูลินทางการค้าที่ระดับ 4% ผลการทดลองพบว่า ที่ระดับการเสริมอินนูลินจากแก่นตะวันที่ระดับ 2 เปอร์เซ็นต์ มีผลทำให้น้ำหนักสิ้นสุดการทดลอง ปริมาณอาหารที่กิน อัตราการเจริญเติบโตต่อตัวต่อวันสูงขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) ในขณะที่พบปริมาณ Lactic acid bacteria ในมูลสูงขึ้น ประสิทธิภาพการกลืนกินแบคทีเรียของเม็ดเลือดขาว (%PA) และดัชนีชี้วัดประสิทธิภาพการทำงานของเม็ดเลือดขาว (IPA) สูงขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) การกินได้ของโปรตีนการย่อยได้ของ OM NDF และ ADF ก็สูงขึ้น ตลอดจนปริมาณกรดไขมันจำเป็นรวม และ propionic acid (C_3) ก็สูงขึ้น ในขณะที่ acetic acid (C_2) butyric acid (C_4) อัตราส่วนระหว่าง $C_2 : C_3$ และ methane (CH_4) ลดลงอย่างมีนัยสำคัญทางสถิติ ($p<0.05$)

การทดลองที่ 2 ทำการศึกษาผลของระดับอินนูลินในอาหารต่อประสิทธิภาพการผลิตของแพะก่อนหย่านม จากการศึกษาในลูกแพะลูกผสมแยกเพศ จำนวน 20 ตัว (Thai native-Anglo-nubian) วางแผนการทดลองแบบสุ่มในบล็อกสมบูรณ์ โดยการทดลองแบ่งเป็น 5 กลุ่มทดลอง ได้แก่ กลุ่มที่ 1 กลุ่มควบคุม กลุ่มที่ 2 การเสริมอินนูลินจากแก่นตะวันที่ระดับ 2% กลุ่มที่ 3 การเสริมอินนูลินจากแก่นตะวันที่ระดับ 4% กลุ่มที่ 4 การเสริมอินนูลินทางการค้าที่ระดับ 2% และกลุ่มที่ 5 การเสริมอินนูลินทางการค้าที่ระดับ 4% ผลการทดลองพบว่า ที่ระดับการเสริมอินนูลินจากแก่นตะวัน ที่ระดับ 2 เปอร์เซ็นต์ มีผลทำให้น้ำหนักแพะ ปริมาณการกินได้ของอาหาร อัตราการเจริญเติบโตต่อตัวต่อวันสูงขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) ในขณะที่พบปริมาณ Lactic acid bacteria ในมูลสูงขึ้น ประสิทธิภาพการกลืนกินแบคทีเรียของเม็ดเลือดขาว (%PA) และดัชนีชี้วัดประสิทธิภาพการทำงานของเม็ดเลือดขาว (IPA) สูงขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) การย่อย-

ได้ของ OM EE NDF และ ADF ก็สูงขึ้นอย่างมีนัยสำคัญยิ่งทางสถิติ ($p<0.01$) ตลอดจนปริมาณกรดไขมันจำเป็นรวม และ propionic acid (C_3) ก็สูงขึ้น ในขณะที่ acetic acid (C_2) butyric acid (C_4) อัตราส่วนระหว่าง $C_2 : C_3$ และ methane (CH_4) ลดลงอย่างมีนัยสำคัญยิ่งทางสถิติ ($p<0.01$)

การทดลองที่ 3 ทำการศึกษาผลของ Synbiotic (อินนูลินจากแก่นตะวันร่วมกับเชื้อแบคทีเรียจำเป็น) ในอาหารต่อประสิทธิภาพการผลิตของลูกแพะก่อนหย่านม จากการศึกษาในลูกแพะลูกผสมแยกเพศ จำนวน 20 ตัว (Thai native-Anglo-nubian) วางแผนการทดลองแบบสุ่มในบล็อกสมบูรณ์ การทดลองใช้อินนูลินจากแก่นตะวันร่วมกับแบคทีเรียจำเป็นทางการค้า (BACTOSAC-P) โดยแบ่งการทดลองออกเป็น 5 กลุ่มทดลอง ได้แก่ กลุ่มที่ 1 กลุ่มควบคุม กลุ่มที่ 2 การเสริม synbiotic ที่ระดับ 0.1% กลุ่มที่ 3 การเสริม synbiotic ที่ระดับ 0.2% กลุ่มที่ 4 การเสริม synbiotic ที่ระดับ 0.3% และกลุ่มที่ 5 การเสริม synbiotic ที่ระดับ 0.4% ผลการทดลองพบว่า Lactic acid bacteria ในมูลสูงขึ้น ประสิทธิภาพการกลืนกินแบคทีเรียของเม็ดเลือดขาว (%PA) และดัชนีชี้วัดประสิทธิภาพการทำงานของเม็ดเลือดขาว (IPA) สูงขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) การใช้ประโยชน์ได้ของ OM NDF และ nitrogen absorption สูงขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) ตลอดจนปริมาณกรดไขมันจำเป็นรวม และ propionic acid (C_3) ก็สูงขึ้น ในขณะที่ acetic acid (C_2) อัตราส่วนระหว่าง $C_2 : C_3$ และ methane (CH_4) ลดลงอย่างมีนัยสำคัญทางสถิติ ($p<0.05$)

สาขาวิชาเทคโนโลยีการผลิตสัตว์
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ลายมือชื่อนักศึกษา_____
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BHUTHARIT VITTAYAPHATTANANURAK RAKSASIRI : ENHANCING THE EFFICIENCY TO UTILISE OF INULIN FROM PLANTS AS A PREBIOTICS IN GOAT KID DIETS. THESIS ADVISOR : ASSOC. PROF. PRAMOTE PAENGKOUM, Ph.D., 163 PP.

GOAT KID/INULIN/PREBIOTIC/SYNBIOTIC/PRODUCTIVE PERFORMANCE

The aim of this research was to study the utilization of inulin extracted from plants and commercial inulin on productive performance, fecal score, hematological traits and nutrient digestibility in goat kids.

The first experiment investigated the effects of inulin in milk on the productive performance of goat kids. Twenty goat kids, Thai native (TN) and Anglo-nubian, were assigned in a randomized block design into five groups during the experimental period. There were five dietary treatments groups : control diet (T1), inulin extract from Jerusalem artichoke supplemented at 2% (T2) and 4% (T3), and commercial inulin supplemented at 2% (T4) and 4% (T5) of the diet (DM), respectively. The results showed that final body weight, feed intake and average daily gains of goat kids supplemented with inulin extract at 2% (T2) were significantly increased ($p<0.05$) compared to the remaining treatments. In addition, supplementation of inulin extract at 2% also resulted in higher lactic acid bacteria population, phagocyte activity (%PA), index of phagocyte activity (IPA), crude protein intake, digestibility of OM, NDF and ADF, and concentrations of total volatile fatty acid (VFA) and propionic acid (C_3), whereas, concentrations of acetic acid (C_2), butyric acid (C_4) and methane (CH_4) and ratios of C_2 to C_3 were significantly decreased ($p<0.05$).

The second experiment investigated the effects of inulin in creep feed on the productive performance of goat kids. Twenty goat kids, Thai native (TN) and Anglo-nubian, were assigned in a randomized block design into five groups during the experimental period. There were five dietary treatments groups : control diet (T1),

inulin extract from Jerusalem artichoke supplemented at 2% (T2) and 4% (T3), and commercial inulin supplemented at 2% (T4) and 4% (T5) of the diet (DM), respectively. The results showed that final body weight, feed intake and average daily gains and of goat kids supplemented with inulin extract at 2% (T2) were significantly increased ($p<0.05$) compared to the remaining treatments. In addition, supplementation of inulin extract at 2% also resulted in higher lactic acid bacteria population, phagocyte activity (%PA), digestibility of OM, EE, NDF and ADF, and concentrations of total volatile fatty acid proportion and propionic acid (C_3), whereas, concentrations of acetic acid (C_2) and methane (CH_4) and ratios of C_2 to C_3 were significantly decreased ($p<0.01$).

The third experiment investigated the effects of inulin in milk on the productive performance of goat kids. Twenty goat kids, Thai native (TN) and Anglo-nubian, were assigned in a randomized block design into five groups during the experimental period. Inulin from Jerusalem artichoke was used as the prebiotic source for specific beneficial microorganisms with (commercial) probiotics (BACTOSAC-P®). There were five dietary treatments groups: control diet (T1), synbiotic supplemented at 0.01% (T2), 0.02% (T3), 0.03% (T4) and 0.04% (T5) of the diet (DM), respectively. The results showed that supplementation of synbiotic at 0.03% and 0.04% of the diet (DM) also resulted in higher lactic acid bacteria population, phagocyte activity (%PA), index of phagocyte activity (IPA), utilization of organic meter, neutral detergent fiber and nitrogen absorption and concentrations of total volatile fatty acid proportion and propionic acid (C_3), whereas, concentrations of acetic acid (C_2) and methane (CH_4) and ratios of C_2 to C_3 were significantly decreased ($p<0.05$).

School of Animal Production Technology

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LISTS OF ABBREVIATIONS

ADF	=	Acid detergent fiber
ADG	=	Average daily gain
BUN	=	Blood urea nitrogen
BW	=	Body weight
CAE	=	Caprine arthritis-encephalitis
CBC	=	Complete blood count
CFU	=	Colony forming unit
CMIR	=	Cell-mediated immune response
CP	=	Crude protein
DM	=	Dry matter
DTH	=	Delayed-type hypersensitivity
FCR	=	Feed conversion ratios
FOS	=	Fructo-oligosaccharide
FPT	=	Failure of passive transfer
GFn	=	Glucose fructose number
GIT	=	Gastrointestinal tract
GOS	=	Galacto-oligosaccharide
HPLC	=	High performance liquid chromatographic
IBD	=	Inflammatory bowel disease
IBS	=	Inflammatory bowel syndrome

LIST OF ABBREVIATIONS (Continued)

Ig	=	Imnunoglobulins
IL-10	=	Interleukin 10
IPA	=	Index phagocytic activity
JA	=	Jerusalem artichoke
MOS	=	Manno-oligosaccharide
MPN	=	Most probable number
NDF	=	Neutral detergent fiber
NRC	=	National Research Council
OM	=	Organic matter
PA	=	Phagocytic activity
PMNs	=	Polymorphonuclesr neutrophils
RBC	=	Red blood cell
SCFA	=	Short-chain fatty acid
SEM	=	Standard error of means
VFA	=	Volatile fatty acid
WBC	=	White blood cell

CHAPTER I

INTRODUCTION

The utilization of antibiotic is restricted in animal feed, thereby the use of prebiotic which is affecting not only animal health is restricted. However, prebiotic has high security and is important in gastroenterology by keeping probiotic, prebiotic is similar to antibiotic but safer.

On account of utilizing prebiotic, the probiotic will develop and the pathogen will disminish. At introduce it will be protected and powerful to utilize prebiotic with probiotic. Jerusalem artichoke contains prebiotics, the critical part is inulin, inulin has fructo-oligosaccharide (FOS). Jerusalem artichoke can increase Bifidobacteria and lactobacilli in the intestinal and reduce pathogen such as *Clostridium* spp. and *Escherichia coli* (Younes et al., 1995; Kaur and Gupta, 2002). In the event that we utilize prebiotic with probiotic we call it cooperative, the probiotic will flourish and include probiotic since they are sub served together, and more probiotic will go to the intestinal (Wanaporn, 2014).

Inulin is a capacity of polysaccharide comprising of a chain of fructose particles. In spite of the fact that it is available in more than 30,000 distinctive vegetable items, Chicory is the real harvest utilized for the modern creation of inulin. Jerusalem artichoke tubers with 14-19% of inulin can likewise be an important wellspring of inulin. Inulin is for the most part popularized as a powder, which accommodates less demanding control, transportation, stockpiling and utilization. The most much of the time utilized technique to acquire this type of inulin is the drying of a fluid concentrate

by splash drying, which requires a lot of vitality (Dobre et al., 2008). Inulin is a polysaccharide that comprises of fructose joined by a beta 2,1 glycosidic bond containing little measures of glucose (one unit of glucose and ≤ 60 fructose units). Inulin is neither processed nor assimilated in the small digestive system however is specifically and immediately aged by microbes in different parts of the wholesome tract empowering multiplication of lactobacillus, basically Bifidobacterium spp. The Bifidogenic instrument depends on particular aging of fructans by bifidobacteria blending beta-fructosidasis, protein breaking down beta 2,1 glycosidic bonds in inulin and oligofructosis. The change of bacterial small scale vegetation in the digestive system, can be seen by the diminishing quantities of hurtful microscopic organisms, because of the bifidogenic impact. Their multiplication is restrained by Bifidobacterium spp. that produces short-chain unsaturated fats (SCFA) and lower the pH of the digestive tract toll, the same realizes unfavorable conditions for pathogens. Also bifidobacteria rival pathogens for attachment's place in intestinal epithelium, for supplements and create anti-infection substances, purported bacteriocins and hydrogen peroxide. Among species where multiplication is discouraged by different strains of bifidobacteria are among others *Escherichia coli*, *Salmonella*, *Shigella*, *Campylobacter jejuni* and *Clostridium perfirgens*. Amid bacterial aging of fructans, short-chain unsaturated fats are delivered, particularly acidic, propionic, lactic and butyric corrosive (Gibson and Roberfroid, 1995). These acids indicate valuable impact on digestion, feed intestinal cells, bring down pH of intestinal chyme and stretch intestinal villuses and in addition increment number of epithelial cells specifically villus (Barbara, 2011).

1.1 Research hypothesis

Supplementation of inulin in the goat kid diets could be improved immune modulation and animal productive performances.

1.2 Research objectives

1.2.1 To study on the inulin productivity in various plant species.

1.2.2 To study the supplementation of inulin in diet on performance and immune modulation of goat kid.

1.3 Scope and limitation of this study

This study will focus on effect of inulin and inulin extraction supplementation in goat kid diet on productive performance, change of intestinal microflora, level of immunoglobulin and goat health condition.

1.4 Expected results

Supplementation of inulin in the goat kid diets increace improved immune modulation and animal productive performances.

1.5 References

Babara, K. (2011). Effect of mannan-oligosaccharides, inulin and yeas nucleotides added to calf milk replacers on rumen microflora, level of serum immunoglobulin and health condition of calves. **Electronic Journal Polish Agricultural Universities**. 14(2): 18.

Dobre, T., Stroescu, M., Stoica, A., Draghici, E., and Antohe, N. (2008). Inulin extraction and encapsulation. **Chemical Bulletin of Politehnica University of Timisoara**. 35: 215-217.

Gibson, G.R., and Roberfroid, B. (1995). Dietary modulation of the human colonic microbiota: Introducing the concept of prebiotic. **Journal of Nutrition**. 125: 1401-1412.

Kaur, N., and Gupta, K. (2002). Applications of inulin and oligofructose in health and nutrition. **Journal of Biosciences**. 27(7): 703-714.

Wanaporn, T. (2014). Alternatives to the use of antibiotics as growth promoters for livestock animal. **Journal of Agricultural**. 30(2): 201-212.

Younes, H., Garleb, K., Behr, S., Rémésy, C., and Demigné, C. (1995). Fermentable fibres or oligosaccharides reduce urinary nitrogen excretion by increasing urea disposal in the rat cecum. **Journal of Nutrition**. 125: 1010-1016.

CHAPTER II

REVIEW OF THE LITERATURE

The definition of prebiotic, inulin, the advantage of inulin for consumers and also factors affecting inulin content in animal was described.

2.1 The definition of prebiotic

Prebiotics are a gathering of bio-particles assembled together by ethicalness of their ability to advance the development and increase of particular gainful gut microflora. Restriction on the utilization of anti-toxins and hormones as encourage added substances, customer mindfulness, strict quality control measures are the driving components for extreme innovative work in the territories of practical nourishment, particularly the prebiotic oligosaccharides, prebiotics might be characterized as non-absorbable sustenance fixings that gainfully influence the host by specifically invigorating the development and additionally action of one or a predetermined number of microorganisms in the colon. As it matches with specific parts of dietary fiber, the refreshed variant of prebiotics incorporates specifically matured fixings that permit particular changes, both in the creation as well as movement in the gastrointestinal microflora that gives benefits upon have prosperity and wellbeing (Gibson et al., 2004). Recently, FAO (2007) characterized the prebiotic as a non-practical nourishment segment that presents a medical advantage on the host related with balance of the organisms. In spite of the fact that the impact of most utilitarian sustenances targets just

a single or a predetermined number of capacities, however the prebiotic focuses on a scope of various physiological capacities including better gut wellbeing, higher mineral assimilation, bringing down of cholesterol, safe incitement and pathogen rejection (Raschka and Deniel, 2005; Roberfroid, 2007). In this way, the prebiotics are portrayed by their non-edibility at gastric levels, particular incitement to the useful gut microflora, natural root and clearly with no buildup issues. It was uncovered that prebiotic inulin is found to display attractive changes in the gut of non-ruminants like poultry, swine, rabbit and so forth to augment gut wellbeing and change of item quality. So also, in ruminants the prebiotic diminishes rumen smelling salts nitrogen, methane generation, increment microbial protein blend and live weight picks up in calves. Dissimilar to other bolster added substances, prebiotic displays its impact in multipronged routes for general increment in the exhibitions of the creatures. In coming days, it is normal that prebiotics could be the piece of eating methodologies in the two ruminants and non-ruminants for empowering regulation of gut microflora opposite creature's profitability in biological ways (Samanta et al., 2013).

Normally utilized prebiotics are oligosaccharides i.e., fructooligosaccharides (FOS), mannonoligosaccharides (MOS), lactulose, inulin. Wellsprings of prebiotics might be characteristic or manufactured. Regular sources are vegetables (oligosaccharides) i.e. field pea, dark gram, chick pea which contain raffinose, stachyose and verbascose. Manufactured oligosaccharides are shaped by coordinate polymerization of disaccharides, fractionation of microbial cells to get the material from cell divider and aging of polysaccharides. Prebiotic should nor be hydrolyzed nor consumed by mammalian proteins or tissues, specifically advance for one or a predetermined number of advantageous microscopic organisms, helpfully change the

intestinal microbiota and their exercises and usefully modify luminal or systemic parts of the host protection framework (Simmering and Blaut, 2001).

Prebiotic should nor be hydrolyzed nor consumed by mammalian catalysts or tissues, specifically enhance for one or a predetermined number of advantageous microscopic organisms, gainfully change the intestinal microbiota and their exercises and valuably modify luminal or systemic parts of the host resistance framework (Samanta et al., 2012). Nevertheless inulin possesses top position in the rundown of prebiotics on account of their accessibility from a wide assets with least cost contribution and incorporates a gathering of biomolecules viz.; inulin, oligofructose and fructooligosaccharides. Inulin and its distinctive structures are available in a wide assortment of plants as regular stockpiling sugars (Samanta et al., 2013). Ruminants are presented to various sort of weight on various events like weaning, transportation, which antagonistically influence the wellbeing of the domesticated animals, bringing about the runs, off encouraged, wretchedness of development, weakened intestinal morphology and so on (Fraser et al., 1998; Nabuurs, 1998). Under such circumstances, environmental treatment through prebiotic might be potential contrasting options to conquer the gut related issues of domesticated animals. By and by economical data is accessible on the impacts of prebiotic in ruminant creatures. All the rumen hemicellulolytic microscopic organisms are able to use xylooligosaccharides as development substrate (Cota and Whitefield, 1998). These are Butyrivibrio fibrisolvens, Eubacterium ruminantium, Ruminococcus albus and so forth. The rumen pH stayed unaltered (6.7), when prebiotic is given to Holstein cows kept up on plantation grass silage or hay silage. In ruminant species, the above pH (6.6 to 6.8) is perfect for development and duplication of valuable plant biomolecules debasing

microscopic organisms (Samanta et al., 2003). A portion of the specialists did not see any huge changes of rumen pH in steers supplemented with prebiotics; be that as it may, they recorded fundamentally higher oxidation decrease potential (Mwenya et al., 2004). The rumen ammonia nitrogen concentration was marginally lower in prebiotics supplemented Holstein cows and controls, which may be because of the use of alkali for microbial protein blend in the rumen (Mwenya et al., 2005; Santoso et al., 2003). Lower rumen ammonia nitrogen concentration in sheep was additionally seen because of prebiotic organization, which might be because of the concealment of alkali delivering microscopic organisms (Mwenya et al., 2004). Dry matter intake, nutrient digestibility is all things considered not influenced by prebiotic supplementation but rather demonstrated higher nitrogen maintenance attributable to expanded microbial protein amalgamation in rumen (Santoso et al., 2003). Consideration of inulin in the drain replacer of pre-ruminant calves prompts essentially higher live weight increases, better dung consistency (Kaufhold et al., 2000; Verdonk and Van Leeuwen, 2004). It is proposed that expansion in body weight may be attributed because of expanded aging at the small digestive tract taken after by expanded stream of microbial nitrogen everywhere digestive system, stable microflora arrangement at rumen, little and internal organ of calves (Verdonk et al., 1998).

Samanta et al. (2012) reported that the fermentation of inulin is faster at pH 6.0 than at neutral pH by rumen inoculums obtained from sheep maintained on sole forage diets (Flickinger et al., 2003). The eating regimen of calves supplemented with oligofructose brought about diminished populace of fecal *Escherichia coli* and add up to anaerobic microflora while Bifidobacteria populace displayed expanding patterns (Bunce et al., 1995). This may be credited by advantageous impacts brought out

through the utilization of prebiotics taken after by their aging at hindgut of calves. Joining of oligofructose in the drain replacer of calves brought about enhanced body weight picks up, nourish transformation productivity with decrease in the frequency of the runs and firmer defecation (Mul, 1997). Consolidation of fructooligosaccharides at a convergence of 0.5% to 1% of aggregate blended proportion (w/w) fundamentally enhanced the natural issue and dry issue edibility of aggregate blended apportion by ideals of adjustment of rumen metabolic profile (Samanta et al., 2012).

2.2 The definition of inulin and advantage of inulin for consumers

Fructose or fruit sugar, is a basic sugar found in nectar, foods grown from the ground plants. It is sweeter than glucose and sucrose. Synthetically it is a monosaccharide with the experimental equation $C_6H_{12}O_6$ the same as glucose yet varies from it in structure. It is best acquired by hydrolysis of polyfructose inulin that is sugar of plant cause actually occuring in noteworthy sums (Coussement, 1999), Fructofuranosyl units in fructans are connected by either β-2-1 or β-2-6 glycosidic bonds and named as needs be inulins or levans (Kasperowicz and Michalowski, 2002). Inulin is present in greater than 36,000 plant species, especially composite, as plant storage carbohydrates (Flickinger et al., 2003). Inulin is a polymer of fructans and comprises basically of direct chains of fructosyl units connected by β (2-1) bonds finished by a glycosyl unit (Dysseler et al., 1999). Native inulin is a blend of poly-and oligosaccharides which all have the concoction structure GFn (G = glucose, F = fructose, and n = number of fructose units connected to each other). The connections between the particles are of an extremely exceptional sort : the β (2-1) frame (2), which makes these atoms inedible for all higher animals (Coussement, 1999). Fructans are

actually found in plants, as well as in microorganisms and organisms, likely serving altogether different capacities. Most bacterial fructans are high atomic weight polymers of the levan sort, i.e., they are composedof β-(2,6)- fructosyl-fructose connected particles and side chains (Marx et al., 1999). Levans are a piece of the exopolysaccharide that shields the cells from parching, helps in surface connection, and is – in some plant pathogenic species – included in keeping the attacking microscopic organisms from being perceived by the host barrier framework (Hettwer et al., 1995 and, Kasapis et al., 1994). Levan is viscous, biologically active, non-toxic and can be utilized as thickener or stabilizer in the sustenance, pharmaceutical and corrective businesses and is a decent crude material for fructose generation, goes about as immunomodulator, and is connected as blood plasma substitute, prolongator of drug, and a cholesterol bringing down specialist (Yamamoto et al., 1999). Inulin could go about as a substitute for sugar or fat, having the upside of low caloric esteem. Likewise, shows some practical properties. It acts in the creature also to dietary strands, adding to the change of the gastrointestinal framework conditions. It was watched that inulin increment thickness, giving body and advancing the surface of low-calorie refreshments and in addition giving spread-capacity to low fat and no fat items, yogurts, serving of mixed greens dressings, mousses, chocolates, and so forth. (Meehye, 2000). A few examinations soothed that dissolvable nonstarch polysaccharide such inulin positively affects cholesterol digestion in rats. Because of these properties, sustenance and pharmaceutical enterprises have discovered applications for inulin in the creation of utilitarian nourishments, dietary composites and prescriptions (Dobre et al., 2008). However little information are accessible on the impact of inulin on microbial combination, however Rosendo et al. (2003).

Concentrate on the effects of the prebiotics inulin and lactulose on intestinal immunology and hematology of pre-ruminant calves have been researched by Masanetz et al. (2011). Both prebiotics essentially diminished thrombocyte tallies in fringe blood. Just inulin could build hemoglobin focus and hematocrit. Add up to leukocyte check was diminished by lactulose while both prebiotics tended to bring down monocyte extents. mRNA articulation of aggravation related markers in the digestive system was likewise influenced by both prebiotics indicating at a diminished provocative status. This might be because of a conceivable lessening in intestinal pathogen stack that remaining parts to be confirmed. Just mRNA measures of interleukin 8 were expanded by lactulose in mesenteric lymph hubs. In the ileum, articulation of an expansion marker was expanded by inulin while an apoptosis-related quality was expanded by both prebiotics. The consequences of this examination demonstrate an unmistakable impact of prebiotics on specific parameters related with creature wellbeing and execution that stay to be contemplated in detail in future examinations.

Inulin is a polydisperse plant polysaccharide, individual from fructan family, comprising primarily of β-(2→1) fructofuranosyl units (Fm), and a terminal α-glycopyranose unit (1→2) (GFn) (Figure 1) (Van Laere and Van Den Ende, 2002). The level of polymerization (DP) of inulin changes from 2 to 70, as atoms with DP 10 are called oligofructoses or fructooligosaccharides (FOSs (Niness, 1999).

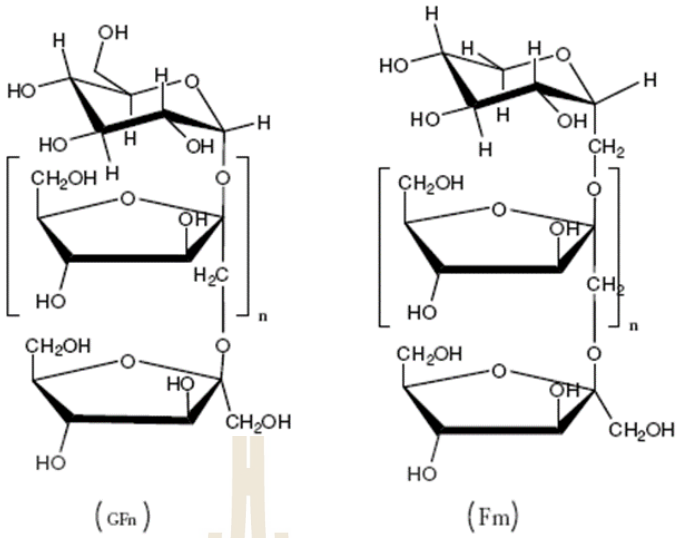

Figure 2.1 Chemical structure of inulin (Van Laere and Van Den Ende, 2002).

Inulin, as a prebiotic, opposes enzymatic processing in the upper gastrointestinal tract; it achieves the colon for all intents and purposes in place to experience bacterial aging. All inulin-sort prebiotics are bifidogenic. They fortify the development of helpful types of microorganisms (Kelly, 2008; Sadra and Eugeniusz, 2013). It is critical to know how much inulin should be added to the bolster to get the best outcomes in both, swelling and nature of delivered meat, from the point of view of manufacturers. Clarification is the main stage in the refining procedures of inulin (Figure 2.2). By and large polluting influences in the inulin remove from Jerusalem artichoke tubers are protein, gums, fiber and cell pieces, and so forth. These polluting influences effectsly affect a portion of the unit operations. Right off the bat a few debasements impact inulin quality. Besides certain polluting influences have a significant impact upon the flocculation procedure required in the development of the calcium sugar combination. As an outcome, such contaminations affect upon the filtration, decolourisation and fixation forms (Wu, 2006).

Inulin is a mind boggling sugar molecule that has profitable effects as a sustenance settling. Inulin is believed to be sustenance settling. Inulin is a polysaccharide involves fructose joined by a beta 2, 1 glycosidic bond containing little measures of glucose (one unit of glucose and ≤ 60 fructose units). Inulin is a limit polysaccharide containing a chain of fructose particles. Inulin is neither handled nor ingested in little stomach related framework anyway it is specifically and quickly ages by infinitesimal living beings in promote segments of healthy tract invigorating increase of lactobacillus, basically Bifidobacterium. Inulin is generally promoted as a powder, which suits less definitively ordering control, transport, stockpiling and usage. The practically occasionally used system to get this kind of inulin is the drying of a liquid think by sprinkle drying, which requires a plenty of essentialness (Dobre et al., 2008). Bifidogenic action segment relies upon specific maturing of fructans by Bifidobacteria synthesing beta-fructosidasis, protein deteriorating beta 2, 1 glycosidic bond in inulin and oligofructosis. Change of bacterial microflora in stomach related framework, included in frightening number of perilous infinitesimal living beings is optically peddled as an outcome of bifidogenic affect. Their increase is subdued by Bifidobacteria that incite short-chain unsaturated fats (SCFA) and lower pH of stomach related framework chyme the same accomplish uncongenial conditions for pathogens. In incorporation Bifidobacteria equal pathogens for addition's place in intestinal epithelium, for supplements and appropriate hostile to microbial substances, claimed bacteriocins and hydrogen peroxide Among species that augmentation is overwhelmed by various trains of Bifidobacteria are had a place with among others *Escherichia coli*, *Salmonella*, *Shigella*, Campylobacter jejuni and *Clostridium perfirgens*. In the midst of bacterial maturing of fructans short-chain unsaturated fats are conveyed, especially

acidic, propionic, lactic and butyric destructive (Gibson and Roberfroid, 1995). These acids indicate worthwhile effect on absorption framework, maintain intestinal cells, bring down pH of intestinal chyme and broaden intestinal villuses and also increase number of epithelial cells specifically villus (Barbara, 2011).

Regardless of the way that inulin is accessible in more than 30,000 vegetable things, chicory is the primary vegetable used for the mechanical engenderment of inulin. Jerusalem artichoke tubers with 14-19% of inulin can be a weighty wellspring of inulin too. Jerusalem artichokes contain huge convergences of prebiotics, particularly inulin. Inulins recovered from Jerusalem artichokes have more conspicuous common development. What's more, Jerusalem artichoke has appeared to build *Bifidobacteria* and *Lactobacilli* focus in the intestinal tract and diminishing pathogens, for example, clostridium and *Escherichia coli* (Younes et al., 1995; Kaur and Gupta, 2002).

2.3 Effect of inulin in livestock

Amid the last one and a half decades there has been developing enthusiasm among the different field of scientists to guarantee multidimensional use of prebiotics for prosperity of human culture (Samanta et al., 2013). Subsequently it discovers its place for enlarging gut wellbeing and usefulness, regularization of fecal yield in more established people, sweetener for diabetic patient, biological treatment of gastrointestinal issue particularly incendiary gut malady and so forth (Gibson et al., 2004; Saito et al., 1992; Van Loo et al., 1995).

2.3.1 Effect of inulin on gut microflora

Reviewed microbial ecology of compoanian creature as take after. Microbiologically, the gut could be tholght of regarding three guideline areas: the stomach, smll digestive tract and colon. For microbial populace, the stomach had low bacterial numbers; facullative anaerobes, for example, lactobacilli, streptococci and yeast were available at around 100 state framing unit (CFU) per milliliter because of the low condition at pH. The amall digestive system had a bigger bacterial load that comprised of facultative anaerobes, for example, Bifidobacterium spp., Bacteroides spp. furthermore, closttidia as levels of roughly 104-108 CFU/ml. the most intensely colonized district, be that as it may, was the colon, with an aggregate populace of 1011-1012 CFU/ml of substance. The colonic microflora was the dominating taget for dietary intercession in the gut nature (Rastall, 2004).

In terms of health, the most significant active organisms are believed to be the bifidobacteria (Gibson and Roberfroid, 1995). Bifidobacteria are the major component of the microbial barrier to the intestinal infection. Bifidobacteria produce a range of anitimicrobial agent that are active against gram-positive and gram- negative organisms (Gibson and Wang, 1994). Lactobacilli are also health positive and produce a range of antimicrobial agents. In addition to the production of antimicrobial agents, a large population of beneficial bacteria competitively excludes pathagens by occupying receptor sites and competing for space, nutrients competitoes etc (Maitreepawit, 2008).

Inulins are dietry parts that are not processed by the host, but rather they advantage the host by specifically animating the development or movement of one or a predetermined number of microscopic organisms in the gastrointestinal tract (GIT). They can possibly balance colonic microflora and debilitate the colonization of enteric

pathogens. Supplementation of inulin has been appeared to upgrade gut wellbeing in a few ways. Their tion utilization may bring about sensational changes in the sythesis of gutmicroflora. Inulin specifically sustain the wellbeing advancing microbes *Bifidobacterium* and lactic corrosive microscopic organisms, for example, *Lactobacillus acidophilus*, *Bifidobacterium* and *Enterococcus faecium* microorganisms can be remedially alluded to as wellbeing advancing or gainful microscopic organisms for some reasons proposed by some exploration contemplates. Each of these species is benefits in both little and internal organs. Be that as it may, the Lactobacillus acidophilus and *Enterococcus faecium* have a tendency to be more dynamic in the small digestive tract, while the *Bifidobacterium* are more dynamic in the lage digestive system. These wellbeing advancing microbes are likewise viewed as lactic corrosive delivering microorganisms and help with maitaning and controlling stomach related tract pH to confine *Escherichia col*i and *Salmonalla* development and the connection or colonization by the benficial microscopic organisms keeps hurtful microbes from joining and expanding in number (Maitreepawit, 2008; Mayer and Sttasse-Wolthuis, 2009; Samanta et al., 2012). Moreover, there were no distinctive differences in fecal score, fecal pH and fecal bacterial populaces (*Escherichia coli*, lactic corrosive microbes and aggregate microorganisms). Kara et al. (2012) examined impacts of inulin supplementation on fecal qualities and soundness of neonatal, milk-fed Saanen kid fecal scores were comparative between gatherings in the present study. Hill et al. (2008), examined impacts of empowering FOS and MOS in dairy calves and found a preposterous measure of development of fructans by colonic microorganisms can provoke extended gas improvement, stomach issues and free defecation. Nevertheless, Flickinger et al. (2003) noticed degradation of inulin is faster at pH 6.0 than at unbiased

pH by rumen inoculums from sheep kept up on sole search diets. The eating routine of calves supplemented with oligofructose brought about diminished populace of fecal *Escherichia coli* and all out anaerobic microflora while Bifidobacteria populace showed expanding patterns (Bunce et al., 1995). This may be credited by gainful impacts brought out through the utilization of prebiotics took after by their aging at hindgut of calves. Joining of oligofructose in the milk replacer of calves brought about enhanced body weight picks up, food transformation productivity with diminishment in the occurrence of the runs and firmer dung (Mul, 1997). In this manner influencing the retention of sustenance. What's more, the capacity to absorb into an alternate creature. Subsequently, creature sustenance, can be utilized as a part of the developing procedure the development has expanded. (Awad et al., 2008). Swanson and Fahey (2002) Said key piece of *Bifidobacteria* and *Lactobacilli* have chemicals break down proteins cluster azoreductase nitroductas nitrate reductase and β-glucuronides low the protein causes these toxic substances. Effect of inulin in jolt devour upon hematological qualities of goat kids. The utilization of inulin with probiotc effectsly affected the general status of the creatures as characterized by low mortality and high generation parameters and the synbiotic thoughts regarding part of movement : changing the association of intestinal microbiota by doable favorable position living thing and non-absorbable living being substrates (Hozan, 2016; Dunislawska et al., 2017).

2.3.2 Effect of inulin on phagocyte activity in animal

Both animal studies suggest that inulins may have resistant modulatory impacts, however so far information are constrained and the outcomes ought to be deciphered deliberately (Meyer and Stasse-Wolthuis, 2009). An unmistakable result of creature thinks about is that the intestinal resistant framework and, particularly, the safe

cells related with the Peyer's patches are receptive to a dietary supplement of inulin/oligofructose as well as their metabolites and for instance, it has been shown that inulin supplementation of rat feed leads to increased production of IL-10 and interferon-gamma (Roller et al., 2004; Seifert andWatzl, 2007). The key instrument for the fruitful result of inflammationis phagocytosis. Phagocytosis is the procedure by which leukocytes inundate trespassers and destrory them by enzymatic corruption. Phagocytosis frees the group of flotsam and jetsam after tissue damage and devastates remote intruders. Of the considerable number of leukocytes, neutrophils and macrophages perform phacocytosis generally effectively. Albeit particular supplements are known to be critical in the improvement and capacity of the resistant framework (Alexander, 1995). It can be theorized that the fermentative property of dietary inulin may have decidedly affected insusceptibility. The insusceptible improving impact of dietaly fiber that adjustments in the intestinal microflora that happen with the utilization of perbiotic fiber may possibly intercede safe changes by means of: the impact contract of lactic corrosive microscopic organisms or bacterial items (cell divider or cytoplasmic parts) with invulnerable in the digestive tract and the generation of shot-chain unsaturated fats from maturation or by changes in mucin creation (Schley and Field, 2002).

Maitreepawit (2008) revealed the innnate invulnerability or nonspecific resistance involves the cells and systems that protect the host from contamination by different living beings, in a non-particular way. This implies the cells of the inborn framework perceive, and react to phathogens blandly, yet dissimilar to the versatile resistant framework. It doss not present dependable or defensive invulnerability to the host. Phagocytosis is an imperative leeway system for the evacuation and aura of

outside specialists and paricles or harmed cell. Macrophages, monocytes and polymorphonuclear cells are phagocytic cells. Phagocytosis of microorganisms includes a few stages: connection, disguise and absorption. After connection, the molecule is immersed inside a layer part and a phagocytic vacuole is fermed. The vacuole wires with the essential lysosome to from the phagolysosome, in which the lysosomal catalysts are released and the encased materal is processed. Remmants of toxic material can be perceived along these lines as remaining bodies. Polymorphonuclesr neutrophils (PMNs), eosinophils and macrophages assume a vital part in guarding the host against microbial contamination. PMNs and periodic eosinophils seem first because of intense aggravation, took after later by macrophages. Chemotactic factors are discharged by effectively duplicating microorganisms. These chemotactic factors are control attractants for phagocytic cells which have particular layer receptors for the elements. Certain pyogenic microorganisms may annihilate not long after phagocytosis because of oxidative responses. Notwithstanding, certain intracellular microorganisms, for example, Mycobacteria or Listeria are not laughtered only by ingestion and many stay vible unless there is satisfactory cell-interceded invulnerability actuated by γ interferon initiation of macrophages as show in Figure 2.3. Immunomodulatory of inulin on the gut-associated lymphoid tissue can easily be investigated in animal (Stephanie and Bernhard, 2007), there are several hypotheses about the effects of inulin on the immune system. It is believed that this effect may be either indirect or direct. An indirect impact refers to the stimulation of the development of beneficial gut microbiota strains, and the inhibition of the proliferation of pathogenic bacteria causing infections and producing toxins harmful to the organism (Izabela et al., 2016).

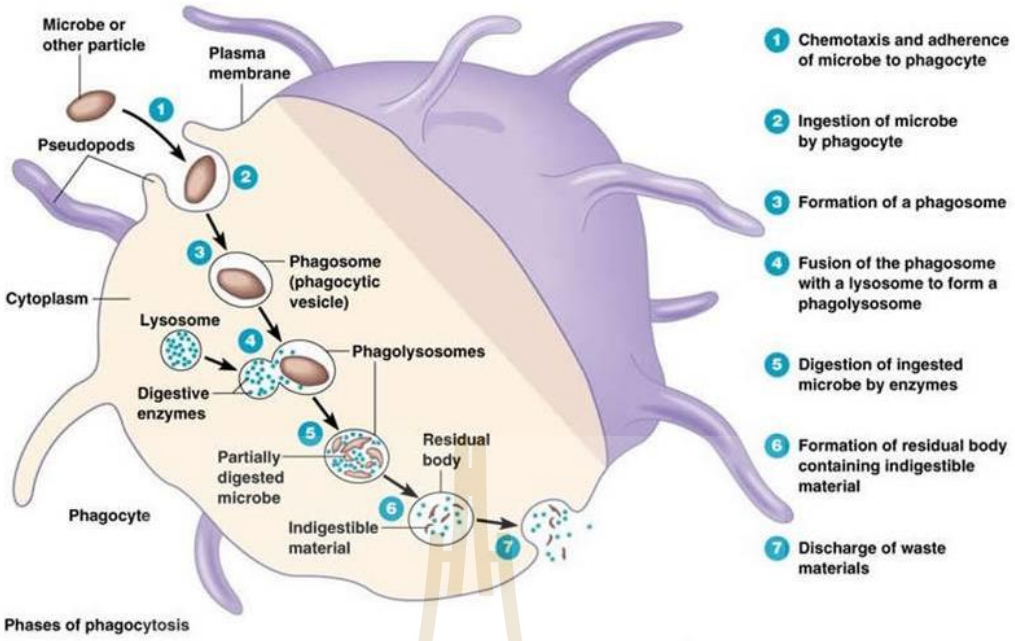

Figure 2.2 Process of phagocytosis activity (Weigang, 2004).

2.3.3 The use of inulin in ruminants

Samanta et al. (2013) explored the foregut and hindgut houses a huge number of assorted gatherings of microflora to be specific microorganisms, growths, yeasts, phage particles, archaea and so on with the exemption that protozoa should be available just at foregut and missing at hindgut. Prebiotics are aged by number of rumen microbes for its use as wellspring of vitality (Cota and Whitefield, 1998; Samanta et al., 2012). The empowering aftereffects of prebiotics on human wellbeing particularly the gut microbial biology have provoked ruminant analysts to investigate its possibility on various domesticated animals species like dairy cattle, wild ox, sheep and so forth. Ruminants are presented to various sort of weight on various events like weaning, transportation, which unfavorably influence the soundness of the domesticated animals, bringing about loose bowels, off nourished, sorrow of development, weakened intestinal morphology and so forth (Fraser et al., 1998;

Nabuurs, 1998). Under such situations, ecological treatment through prebiotic may be potential alternatives to overcome the gut associated problems of livestock.

In ruminant species, the above pH (6.6 to 6.8) is ideal for growth and multiplication of useful plant biomolecules degrading bacteria (Samanta et al., 2003). A portion of the scientists did not see any huge changes of rumen pH in steers supplemented with prebiotics; notwithstanding, they recorded essentially higher oxidation diminishment potential (Mwenya et al., 2004). The rumen alkali nitrogen fixation was marginally lower in prebiotics supplemented Holstein cows and guides, which may be because of the use of smelling salts for microbial protein amalgamation in the rumen (Mwenya et al., 2005; Santoso et al., 2003). Lower rumen ammonia nitrogen concentration in sheep was likewise seen because of prebiotic organization, which might be because of the concealment of smelling salts delivering microbes (Mwenya et al., 2004). Dry issue admission, supplement absorbability is all things considered not influenced by prebiotic supplementation but rather indicated higher nitrogen maintenance attributable to expanded microbial protein union in rumen (Santoso et al., 2003). Consideration of inulin in the drain replacer of pre-ruminant calves prompts essentially higher live weight increases, better dung consistency (Kaufhold et al., 2000; Verdonk and Van Leeuwen, 2004). It is proposed that expansion in body weight may be attributed because of expanded maturation at the small digestive tract taken after by expanded stream of microbial nitrogen everywhere digestive system, stable microflora arrangement at rumen, little and internal organ of calves (Verdonk et al., 1998). The aging of inulin is quicker at pH 6.0 than at unbiased pH by rumen inoculums acquired from sheep kept up on sole rummage diets (Flickinger et al., 2003). Kara et al. (2012), report the inulin supplemented to kids did not unfavorably influence fecal score. Inulin supplementation diminished fecal pH, impact of inulin was

not reliable. Inulin had no critical consequences for chose fecal bacterial populaces, body weight, hematological parameters, wellbeing status and the rate of loose bowels. Weaning is a distressing occasion, which may bargain safe frameworks, because of progress in the eating routine and is related with undesirable changes in bacterial populace in the digestive tract. In this way, the utilization of inulin might be more helpful amid the weaning time frame. We recommended that day by day measurement (0.6 g) of inulin for children won't not be sufficient to watch impacts of it. Extra examinations with supplementing amid the weaning time frame and with higher dosages and additionally extraordinary spans of supplementation are required to assess whether the utilization of inulin for kids and other youthful ruminants emphatically influence execution and wellbeing status. The discoveries of our investigation was valuable to enable further to investigate the measurements and timing of inulin supplementation in kids.

2.4 The definition of synbiotic

The term synbiotic is utilized when an item contains the two probiotics and prebiotics. Since the word suggests synergism, this term ought to be held for items in which the prebiotic compound specifically supports the probiotic compound. In this strict sense, an item containing oligofructose and probiotic bifidobacteria would satisfy the definition, while an item containing oligofructose and a probiotic *Lactobacillus* casei strain would not. In any case, one may contend that synergism is accomplished in vivo by ingestion of lactobacilli from one viewpoint and advancement of indigenous bifidobacteria then again, entirely the type of synbiotics, prebiotics are promptly accessible substrates for probiotics to develop better and enhance the survival of them (Jürgen and Michael, 2001; Collins and Gibson, 1999). Moreover, synbiotic could

increase the digestibility and availability of many nutrient elements such as, vitamins, mineral elements and proteins (Naji, 2009). Synbiotic is composed to show helpful microorganisms populaces, as well as to advance multiplication of autochthonous-particular strains in the intestinal tract and results on in vivo trials are promising, either in youthful creatures or grown-ups : the coupling of a probiotic and prebiotic could likewise yield a synergistic impact in the lessening of sustenance borne pathogenic bacterial populaces in nourishment creatures preceding butcher (Gourbeyre et al., 2011; Bomba et al., 2002). Studies on the effects of synbiotic on metabolic wellbeing still are constrained. It merits specifying that the wellbeing impact will probably rely upon the synbiotic mix. Hence, synbiotics appear to be encouraging for the adjustment of the gut microbiota organization (Hozan, 2016).

Table 2.1 Examples of list of probiotic, prebiotic and synbiotic applied or studied for application in animal feed (Hozan, 2016).

Probiotic	**Prebiotic**	**Synbiotic**
Lactobacillus sps.	Inulin	Lactobacilli + inulin
Bifidobacterium sps.	Galactooligosaccharides (GOS)	Bifidobacteria + FOS
Saccharomyces sps.	Fructo-oligosaccharides (FOS)	Lactobacilli + FOS
Streptococcus sps.	Lactulose	Bifidobacteria and Lactobacilli + inulin
Bacillus coagulans	Lactitol	Bifidobacteria and Lactobacilli + FOS
Propionibacterium	Cereals fibres	Lactobacilli + lactitol
Bacillus coagulans	Xylooligosaccharides	Bifidobacteria + GOS
Enterococcus faecium	Isomaltooligosaccharides	
Freudenreichii		
Homeostatic Soil		

Table 2.2 Micro-organisms authorized for the use as feed additives in the EU (Simon et al., 2003).

Micro-organism	Strain	Species or category of animal
Bacillus cereus var. toyoi	NCIMB 40112/ CNCM I 10121	Chickens for fattening, laying hens, calves, cattle for fattening, breeding does, rabbits for fattening, piglets, saw
Saccharomyces cerevisiae	NCYC sc 47	Rabbits for fattening, sow, piglets, dairy cows.
Saccharomyces cerevisiae	CBS 493.94	Calves, cattle for fattening, dairy cows.
Saccharomyces cerevisiae	CNCM I- 1079	Sows, piglets.
Saccharomyces cerevisiae	CNCM I- 1077	Dairy cows, cattle for fattening
Enterococcus faecium	ATCC 53519 ATCC 55593	Chickens for fattening
Pediococcus acidilactici	CNCM MA 18/5M	Chickens for fattening, pigs, piglets for fattening
Enterococcus faecium	NCIMB 10415	Chickens for fattening, pigs for fattening, sows, cattle for fattening, piglets, calves
Enterococcus faecium	DSM 5464	Piglets, chickens for fattening, calves
Lactobacillus farciminis	CNCM MA 67/4R	Piglets

Table 2.2 Micro-organisms authorized for the use as feed additives in the EU (Simon et al., 2003) (Continued).

Micro-organism	Strain	Species or category of animal
Enterococcus faecium	DSM 10663/NCIMB 10415	Piglets, calves, chickens for fattening.
Saccharomyces cerevisiae	MUCL 39885	Piglets, cattle for fattening
Enterococcus faecium	NCIMB 11181	Calves, piglets
Lactobacillus rhamnosus	DSM 7134	Calves, piglets
Lactobacillus casei	NCIMB 30096	Calves
Enterococcus faecium	NCIMB 30098	Calves
Enterococcus faecium	CECT 4515	Calves, piglets
Streptococcus infantarius	CNCM I-841	Calves
Lactobacillus plantarium	CNCM I-840	Calves
Bacillus licheniformis	DSM 5749	Sow, piglets, pigs for fattening, chickens for fattening, turkeys for fattening, calves.
Bacillus subtilis	DSM 5750	
Enterococcus faecium	DSM 3530	Calves

2.5 Jerusalem artichoke

The Jerusalem artichoke was first developed by Native Americans some time before the landing of the Europeans, and was called sunroots. Following first experience with Europe, different Latin and regular names were credited to Jerusalem artichoke. Kays and Nottingham (2007) gathered and revealed almost 100 normal names utilized as a part of various dialects. Presently probably the most regularly utilized English names incorporate Jerusalem artichoke, sunchoke, topinambur, forest sunflower or earth apple. Strikingly, the name Jerusalem artichoke is deceiving as it is a kind of sunflower in an indistinguishable variety from the garden sunflower; be that as it may, it has no connection to Jerusalem, nor is it a sort of artichoke (Lindsayjean, 2013; Linxi et al., 2015). Inulin was a diet to bacteria and with lactic acids and short-chain fatty acids as end products causing acidic condition in gastrointestinal and reduce Clostridium perfringens, Salmonella spp. and *Esherichia coli* (Raksasiri et al., 2014). Jerusalem artichoke is a characteristic crude material for the induction of various practical sustenance fixings, for example, inulin, oligofructose and fructose, having both dietary and useful qualities, especially gainful to people with Type 2 diabetes and weight (Barta and Rosta, 1958; Roberfroid, 1993; Bornet, 1994; Niness, 1999; Roberfroid, 2002). Jerusalem artichoke is a tuberous annual crop of which tubers are rich in fructo-origosaccharide (FOS) carbohydrates in the froms of inulin and fructand. The FOS are not digestible by the animal digestive enzymes but are readily digested by the beneficial micicrobes in GI tract. Feeding FOS to animals suppesses growth and proliferation of the GI pathogenic bacteria but stimulates growth of health-promoting microbials with beneficial implications for host health. Feeding FOS from Jerusalem artichoke to animals helped improve gut health by balancing microbial population,

lowering intestinal pH and sitimulating development of gut wall resulting in improved absorption (Khajarern et al., 2006; Linxi, 2015).

Figure 2.3 Jerusalem artichoke, Helilanthus L-Sunflower (*Helianthus tubersosus* L.); picture by Raksasiri B.V. (August 5, 2016).

2.6 References

Alexander, J.W. (1995). Specificnutriens and the immune response. **Journal of Nutrition**. 11: 229-232.

Awad, W., Ghareeb, K., and Böhm, J. (2008). Intestinal structure and function of Broiler chickens on diets supplemented with a symbiotic containing Enterococcus faecium and oligosaccharides. **International Journal of Molecular Sciences**. 9: 2205-2216.

Babara, K. (2011). Effect of mannan-oligosaccharides, inulin and yeas nucleotides added to calf milk replacers on rumen microflora, level of serum immunoglobulin and health condition of calves. **Electronic Journal of Polish Agricultural Universities**. 14(2): 18.

Barta, L., and Rosta, J. (1958). Effect of Jerusalem artichoke honey-containing isocaloric diet on the sugar metabolism of diabetic children, **Gyermekgyogyaszat**. 9 (8-9): 280-283.

Bomba A., Nemcova R., Mudronova D., and Guba P. (2002). The possibilities of potentiating the efficacy of probiotics. **Trends in Food Science and Technology**. 13: 121-126.

Bornet, F.R. (1994). Undigestible sugars in food products. **The American Journal of Clinical Nutrition**. 59: 763-769.

Bunce, T.J., Howard, M.D., Kerley, M.S., and Allece, G.I. (1995). Feeding fructooligosaccharides to calves increased Bifidobacterium and decreased *Escherichia coli*. **Journal of Animal Science**. 73: 281.

Collins, M.D., and Gibson, G.R. (1999). Probiotics, prebiotics, and synbiotics: approaches for modulating the microbial ecology of the gut. **American Journal of Clinical Nutrition**. 69: 1052-1057.

Cota, M.A., and Whitefield, T.R. (1998). Xylooligosaccharides utilization by ruminal anaerobic bacterium Selemonas ruminantium. **Current Microbiology**. 36: 183-189.

Coussement, P. (1999). Inulin and oligofructose as dietary fiber: analytical, nutritional and legal aspects. In S.S. Cho, L. Prosky, and M. Dreher (eds.) **Complex Carbohydrates in Foods** (pp 203-212). New York: Marcel Dekker, Inc.

Dobre, T., Stroescu, M., Stoica, A., Draghici, E., and Antohe, N. (2008). Inulin Extraction and Encapsulation. **Chemical Bulletin of Politehnica University of Timişoara**. 53(67): 1-2.

Dunislawska, A., Slawinska, A., Stadnicka, K., Bednarczyk, M., Gulewicz, P., Jozefiak, D., and Siwek, M. (2017). Synbiotics for broiler chickens - In Vitro design and evaluation of the influence on host and selected microbiota populations following In Ovo delivery. **PLoS ONE Tenth Anniversary**. 12(1): e0168587.

Dysseler, P., Hoffem, D., Fockedey, J., Quemener, B., Thibault, J.F., and Coussement, P. (1999). Determination of inulin and oligofructose in food products. In S.S. Cho, L. Prosky, and M. Dreher (eds.). **Complex Carbohydrates in Foods** (pp 213-227). New York: Marcel Dekker, Inc.

FAO. (2007). FAO technical meeting on prebiotics [On-line]. Available: http://www.fao.org/ ag/agn/files/prebiotics_tech_meeting_report.pdf.

Flickinger, E.A., Loo, J.V., and Fahey, G.C. (2003). Nutritional responses to the presence of inulin and oligofructose in the diets of domesticated animals: a review. **Critical Reviews in Food Science and Nutrition**. 43: 19-60.

Fraser, D., Milligan, B.N., Pajor, E.A., Philips, P.A., Taylor, A.A., and Weary, M.A. (1998). Behavioral perspectives on weaning in domestic pigs. In: M.A. Varley and J.P. Chadwick (eds.). **Pig Science** (pp 121-138). Nottingham: Nottingham University Press.

Flickinger, E.A., Van Loo, J., and Fahey, G.C. (2003). Nutritional responses to the presence of inulin and oligofructose in the diets of domesticated animals; a review. **Critical Reviews in Food Science and Nutrition**. 43: 19-60.

Gibson, G.R., and Wang X. (1994). Inhibitory effects of bifidobacteria on other colonic bacteria. **Journal Applied Bacteriology**. 77: 412-420.

Gibson, G.R., and Roberfroid, M.B. (1995). Diatary modulation of human colonic microbiota: introducing the concept of prebiotics. **Journal of Nutrition**. 125: 1401-1412.

Gibson, G.R., Probert, H.M., Rastall, R.A., and Roberfroid, M.B. (2004). Dietary modulation of the human colonic microbiota: Updating the concept of prebiotics. **Nutrition Resrarch Reviews**. 17: 259-275.

Gourbeyre, P., Denery, S., and Bodinier, M. (2011). Probiotics, prebiotics, and synbiotics: Impact on the gut immune system and allergic reactions. **Journal of Leukocyte Biology**. 89: 685-695.

Hettwer, U., Gross, M., and Rudolph, K. (1995). Purification and characterization of an extracellular levansucrase from Pseudomonas syringae pv. Phaseolicola. **Journal of Bacteriology**. 177: 2834-2839.

Hill, J.C., Dunn, K.M., Lewis, M., Mullis, R., Main, C.J., and Foster, N.E. (2008). A primary care back pain screening tool; identifying patient subgroups for initial treatment. **Arthritis and Rheumatology**. 59: 632-641.

Hozan, J. H. (2016). Synbiotic as feed additives relating to animal health and performance. **Advances in Microbiology**. 6: 288-302

Izabela, K., Joanna, M.P., and Marek B. (2016). Beneficial aspects of inulin supplementation as a fructooligosaccharide prebiotic in monogastric anmal nutrition. **Annals of Animal Science**. 16(2): 315-331.

Jürgen, S., and Michael, de V. (2001). Probiotics, prebiotics, and synbiotics-approaching a definition. **The American Journal of Clinical Nutrition**. 73: 361-364.

Kara, C., Orman, A., Gencoglu, H., Kovanlıkaya, A., Meral, Y., Cetin, I., Yıbar, A., Kasap, S., Turkmen, I., and Deniz, G. (2012) Effects of inulin supplementation on selected fecal characteristics and health of neonatal Saanen kids sucking milk from their dams. **Animal**. 6: 1947-1954.

Kasapis, S., Morris, E.R., Gross, M., and Rudolph, K. (1994). Solution properties of levan polysaccharide from Pseudomonas syringae pv. phaseolicola, and its possible primary role as a blocker of recognition during pathogenesis. **Carbohydrate Polymers**. 23: 55-64.

Kasperowicz, A., and Michalowski, T. (2002). Assessment of the fructanolytic activities in the rumen bacterium Treponema saccharophilum strain S. **Journal of Applied Microbiology**. 92: 140-146.

Kaufhold, J.N., Hammon, H.M., and Blum, J.W. (2000). Fructooligosaccharides supplementation effects on metabolic, endocrine and hematological traits in vela calves. **Journal of Vetrinary Medicince**. 47: 17-29.

Kays, S.J., and Nottingham, S.F. (2007). **Biology and chemistry of Jerusalem artichoke: *Helianthus tuberosus* L.** Boca Raton, FL: CRC press.

Kelly, G. (2008). Inulin-type prebiotics: a review. (Part 1). **Alternaive Medicine Review**. 13(4): 315-329.

Khajarern, J., Siriloaphaisan, S., and Thisong, P. (2006). Kaentawan (Jerusalem artichoke) in animal feeds. **Khon Kaen Agricultueral**. 34(2): 91-103.

Kaur, N., and Gupta, A.K. (2002). Applications of inulin and oligofructose in health and nutrition. **Journal of Bio-science**. 27: 703-714.

Lindsayjean, N. (2013). Jerusalem artichokes: nothing about this name is right, Food. 52.

Linxi, Y., Quan, S.H., Kenneth, C., and Chibuike C.U. (2015). The prospects of Jerusalem artichoke in functional food ingredients and bioenergy production. **Biotechnology Reports**. 5: 77-88.

Maitreepawit, S. (2008). The effects of fructooligosaccharide supplementation on gut microflora, nutrient digestibility, plasma cholesterol and phagocyte activity in adult dogs. A thesis submitted in partial fulfillment of the requirements for the degree of master of scienceprogram in animal nutrition department of animal husbandry, faculty of veterinary science, Chulalongkorn University. 53 p.

Marx, S.P., Winkler, S., and Hartmeier, W. (1999). Fermentation of levan-oligosaccharides by different Bifidobacterium spaces, Med. Fac. Landbouww. **University Gent**. 64 (5): 335-338.

Masanetz, S., Preißinger, W., Meyer, H. H. D., and Pfaffl, M. W. (2011). Effects of the prebiotics inulin and lactulose on intestinal immunology and hematology of preruminant calves. **Animal**. 5(7): 1099-1106.

Meehye, K. (2000). The water-soluble extract of chicory reduces cholesterol uptake in gut-perfused rats. **Nutrition Research**. 20(7): 1017-1026.

Meyer, D., and Stasse-Wolthuis, M. (2009). The bifidogenic effect of inulin and doligofructose and its consequences for gut heaith. **European Journal of Clinical Nutrition**. 63: 1277-1289.

Mul, A.J. (1997). Application of oligofructose in animal feeds. In: **Proceedings of International Symposium Non-Digestible Oligosaccharides: Healthy Food for colon?** (pp 106). The Netherlands: Wageningen.

Mwenya, B., Santoso, B., Sar, C., Gamo, Y., Kobayashi, T., Arai, I., and Takahashi, J. (2004). Effects of including beta 1,4-galactooligosaccharides, lactic acid

bacteria or yeasts culture on methanogenesis as well as energy and nitrogen metabolism in sheep. **Animal Feed Science and Technology**. 115: 313-326.

Mwenya, B., Sar, C., Santoso, B., Gamo, Y., Kobayashi, T., Morikawa, R., Takura, K., Umetsu, K., Kogawa, S., Kimura, K., Mizukoshi, H., and Takahashi, J. (2005). Comparing the effects of beta 1,4-galactooligosaccharides, and L-cysteine to monensin on energy and nitrogen utilization in steers fed a very high concentrate diets. **Animal Feed Science and Technology**. 118: 19-30.

Nabuurs, M.J.A. (1998). Weaning piglets as a model for studying pathophysiology of diarrhoea. **Veterinary Quarterly**. 20: 42-45.

Naji, S.A.H., Al-kassie, G.A., Al-Hadithi, M.F., Al-Hillali, A.H., and Jameel, Y.J. (2009). Poultry Health Management. Brochure No. 27. Iraqi Poultry Producer Association. (In Arabic).

Niness, K.R. (1999). Inulin and oligofructose: What are they. **Journal of Nutrition**. 129: 1402-1406.

Raksasiri, B.V., Vorlaphim, T., Khotsakdee, J., Paengkoum, S., and Paengkoum, P. (2014). The study of nutritive values and *in vitro* gas production of Jerusalem Artichoke with pangola hay as roughage. In **Proceedings of the 16th AAAP Animal Science Congress** (pp 1807-1809). Yogyakarta, Indonesia: Gadjah Mada University.

Raschka, L., and Deniel, H. (2005). Mechanism underlying the effects of inulin types fructans on calcium absorption in the large intestine of rats. **The Bone and Joint**. 37: 728-735.

Rastall, R.A. (2004). Bacterial in the gut: friends and foes and how to alter the balance. Waltham international science symposium. **Amarican Journal of Clincal Nutrition**. 134: 2022-2026.

Roberfroid, M.B. (2002). Functional food: concepts and application to inulin and oligofructose. **British Journal of Nutrition**. 87: 139-143.

Roberfroid, M. (1993). Dietary fiber, inulin, oligofructose: a review comparing their physiological effects. **Critical Reviews in Food Science and Nutrition**. 33: 103-148.

Roberfroid, M. (2007). Prebiotics: The concept revisited. **Journal of Nutrition**. 137: 830-837.

Roller, M., Rechkemmer, G., and Watzl, B. (2004). Prebiotic inulin enriched with oligofructose in combination with the probiotics *Lactobacillus rhamnosus* and *Bifidobacterium lactis* modulates intestinal immune functions in rats. **Journal of Nutrition**. 134: 153-156.

Rosendo, O., Hall, M., Staples, C., and Bates, D. (2003). The effect of different neutral detergent soluble polysaccharides in digestive cynetics *in vitro* of neutral detergent forage fiber and the synthesis of microbial protein [On-line]. Available: http://revistas.luz. edu.ve/index.php/rc/article/ viewFile/4560/4428

Saito, Y., Takano, T., and Rowland, I. (1992). Effect of soybean oligosaccharides on the human gut microflora in *in vitro* culture. **Mocrobial Ecology in Health and Disease**. 5: 105-111.

Samanta, A.K., Singh, K.K., Das, M.M., Maity, S.B., and Kundu, S.S. (2003). Effect of complete feed block on nutrient utilization and rumen fermentation in Barbari goats. **Small Ruminant Research**. 48: 95-102.

Samanta, A.K., Natasha, J., Senani, S., Kolte, A.P., and Manpal, S. (2013). Prebiotic inulin: Useful dietary adjuncts to manipulate the livestock gut microflora. **Brazilian Journal of Microbiology**. 44(1): 1-14.

Samanta, A.K., Senani, S., Kolte, A.P., Sridhar, M., Sampath, K.T., Jayapal, N., and Devi, A. (2012). Production and in vitro evaluation of xylooligosaccharides generated from corn cobs. **Food and Bioproducts Processing**. 90: 466-474.

Sandra, S., and Eugeniusz, R.G. (2013). Effect of inulin extraction method and level in growing-finishing pig diets on performance, carcass traits and nutritions digestibility. **Annales Universitatis Mariae Curie-SKŁODOWSKA Lublin-Polonia**. XXXI(2): 56-64.

Santoso, B., Kume, S., Nonaka, K., Gamo, Y., Kimura, K., and Takashi, J. (2003). Influence of beta galactooligosaccharide supplementation on nitrogen utilization, rumen fermentation and microbial nitrogen supply in dairy cows fed silage. **Asian-Australasian Journal of Animal Science**. 26: 1137-1142.

Schley, P.D., and Field C.J. (2002). The immune-enhancing effects of dietary fibers and prebiotics. **British Journal of Nutrition**. 87: 221-230.

Seifert, S., and Watzl, B. (2007). Inulin and oligofructose: review of experimental data on immune modulation. **Journal of Nutrition**. 137: 2563-2567.

Simmering, R., and Blaut, M. (2001). Pro- and prebiotics--the tasty guardian angles?. **Applied Microbiology and Biotechnology**. 55: 19-28.

Simon, O., Vahjen, W., and Scharek, L. (2003). Micro-organisms as feed additives-probiotics. In **Proceedings of the 9th International Symposium on Digestive Physiology in Pigs** (pp 295-318). Banff, Alberta: Canada.

Stephanie, S., and Bernhard, W. (2007). Inulin and oligofructose: review of experimental data on immune modulation 1-4. **Journal of Nutrition**. 137: 2563-2567.

Swanson, K.S., and Fahey, G.C. (2002). Prebiotics in companion animal nutrition. In T.P. Lyons and K.A. Jacques (eds.). **Biotechnology in the feed industry. Proc. Alltech's 18th Ann. Symp** (pp 461-473). Loughborough, UK.: Nottingham University Press.

Van Laere, A., and Van Den Ende, W. (2002). Inulin metabolism in dicots: chicory as a model system. **Plant, Cell and Enviroment**. 25: 803-813.

Van Loo, J., Coussement P., De Leenheer, L., Huybregs H., and Smits G. (1995). On the presence of inulin and oligofructose as natural ingredients in the western diets. **Critical Review in Food Science and Nutrition**. 35: 525-552.

Verdonk, J.M.A.J., Beelan, G.M., Jansman, A.J.M., and Huisman, J. (1998). Effect of soya carbohydrate fractions on the ileal digestibility and endogenous flow of nitrogen in veal calves. In A.J.M. Jansman, G.D. Hill, J. Huisman, and A.F.B Vander Poel (eds.). **Recent Advances of Research in Antinutritional Factors in Legume Seeds** (pp 341-343). The Netharlands: Wageningen.

Verdonk, J.M.A.J., and Van Leeuwen, P. (2004). The application of inulin type fructans in diets for veal calves and broilers. In **Inulin and Oligofructose Feed Good Factors for Health and Well Being. 4th Orafti Research Conference**. Paris.

Weigang. (2004). Phagocytosis cativity [On-line]. Available: http://diverge.hunter. cuny. edu/~weigang/Lecture-syllabus.html.

WU, H X. (2006). Studies on the extraction and purification technology of Puna chicory inulin. Xi'an: Northwest A&F University.

Yamamoto, Y., Takashi, Y., Kawano, M., Jizuka, M., Matsumoti, T., Seiki, S., and Yamaguchi, H. (1999). *In vitro* digestibility and fermentability of levan and its

hypocholesterolic effects in rats. **Journal of Nutritional Biochemistry**. 10: 13-18.

Younes, H., Garleb, K., Behr, H., Remesy, C., Remesy, C., and Demigne, C. (1995). Fermentable fiber or oligosaccharide reduce urinary nitrogen excretion by increasing urea disposal in the rat cecum. **Journal of Nutrition**. 125: 1010-1016.

CHAPTER III

EXPERIMENT I

EFFECT OF INULIN IN MILK ON PRODUCTIVE PERFORMANCE AND HEMATOLOGICAL TRAITS OF GOAT KIDS

3.1 Abstract

The objectives of this study was to determine an optimal dose of inulin supplementation to enhance future investigating the effects on parameters associated with performance, immune modulation, or health status in goat kids. Inulin from Jerusalem artichoke as the sources of prebiotic. The number of Thai native-Anglo-nubian kids (n = 20), during the experimental period, were given only milk on days 1-30, thereafter, days 31-75, they were fed with concentrate and roughage, and amount of milk decreased until weaned, and days 76-90, goats were only concentrate and roughage or each. There were five dietary treatments groups; control diet (T1), inulin extracted supplemented 2% (T2) and 4% (T3), and commercial inulin supplemented 2% (T4) and 4% (T5) of diet (DM), respectively. The results showed that final body weight, feed intake and average daily gains were significantly different ($p<0.05$) specifically the supplementation of inulin extract at 2% (T2). In addition, were highly increase of Lactic acid bacteria, percentages of phagocyte activity (%PA), index of phagocyte activity (IPA), crude protein intake, percentagse digestibility (OM, NDF and

ADF), total volatile fatty acid and propionic acid (C_3). While, were decrease of acitic acid (C_2), butyric acid (C_4), ratios of C_2 : C_3, and methane (CH_4) was significantly different ($p<0.05$), among dietary treatments. However, sex was not found to affect experimental.

Keywords : Goat kid, Inulin, Prebiotic, Jerusalem artichoke and Ruminant

3.2 Introduction

The utilization of antibiotic restricted in animal feed, thereby the use of prebiotic which affecting not only animal health. However, prebiotic high security and important in gastroenterology by keeping probiotic, because prebiotic be similar to antibiotic but safe than. In case use prebiotic, the probiotic will thrive and the pathogen will reduce. At present in case use prebiotic with probiotic was safe and effective. In Jerusalem artichoke have prebiotics. In the important is inulin, inulin have fructo-oligosaccharide (FOS). Jerusalem artichoke can make bifidobacteria and lactobacilli increase in intestinal and reduce pathogen such as clostridium and Escherichia coli (Younes et al., 1995; Kaur and Gupta, 2002). In case use prebiotic with probiotic or we call synbiotic, the probiotic will thrive than add only probiotic because they are subserve together. Inulin is a natural component of several plants and a type of polysaccharide in the fructan group; its nutritional properties are an essential part of maintaining overall gastrointestinal health through stimulation of bacterial growth, inhibition of pathogens, and nourishment of probiotics. Inulin is considered to be an extremely important prebiotic by development of microscopic organisms, acidophilus, bifid us and faecium, and by providing the digestive system with fruto-oligosaccharides (FOS). Inulin is a complex sugar particle that has valuable impacts as a sustenance

fixing. Inulin is thought to be nourishment fixing. Inulin is a polysaccharide comprises fructose joined by a beta 2, 1 glycosidic bond containing little measures of glucose (one unit of glucose and ≤ 60 fructose units). Inulin is a capacity polysaccharide comprising of a chain of fructose particles. Inulin is neither processed nor ingested in small digestive system however it is selectively and immediately ages by microscopic organisms in further components of wholesome tract animating multiplication of lactobacillus, principally Bifidobacterium. Inulin is for the most part popularized as a powder, which accommodates less authoritatively mandating control, conveyance, stockpiling and utilization. The most every now and again utilized technique to get this type of inulin is the drying of a fluid concentrate by splash drying, which requires a plethora of vitality (Dobre et al., 2008). Bifidogenic activity component depends on particular aging of fructans by bifidobacteria synthesing beta-fructosidasis, protein disintegrating beta 2,1 glycosidic bonds in inulin and oligofructosis. Change of bacterial microflora in digestive system, comprised in dismaying number of unsafe microscopic organisms is optically canvassed as a consequence of bifidogenic impact. Their multiplication is repressed by bifidobacteria that engender short-chain unsaturated fats (SCFA) and lower pH of digestive system chyme the same achieve uncongenial conditions for pathogens. In integration bifidobacteria rival pathogens for annexation's place in intestinal epithelium, for supplements and distribute anti-microbial substances, alleged bacteriocins and hydrogen peroxide Among species that multiplication is daunted by different trains of bifidobacteria are had a place with among others Escherichia coli, Salmonella, Shigella, Campylobacter jejuni and Clostridium perfirgens. Amid bacterial aging of fructans short-chain unsaturated fats are delivered, particularly acidic, propionic, lactic and butyric corrosive (Gibson and Roberfroid, 1995). These acids show advantageous impact on digestion system, sustain

intestinal cells, lower pH of intestinal chyme and extend intestinal villuses and in addition increment number of epithelial cells in particular villus (Barbara, 2011). This research has purpose for study usage inulin extracted from Jerusalem artichoke and commercial inulin for increase the productive performance and immune modulation of goat kids.

3.3 Objective

The objective of this experiment was to investigate the effects of inulin extract in milk replacer on productive performance and immune modulation of goat kids.

3.4 Materials and methods

3.4.1 Inulin of Jerusalem artichoke

Total N was determined using the Kjeldahl method and crude protein (CP) was calculated by multiplying the N content by 6.25, ether extract (EE) contents were quantified by AOAC (1995). Neutral detergent fiber (NDF) estimated by the methods described by Van Soest et al. (1991). The inulin extract from Jerusalem artichoke tubers was obtained by means of multistage countercurrent extraction technology, and then stored in a refrigeratory at 4°C. The extract was bathed to ambient temperature when used. The process of carbonation, the required amounts of lime (powdered lime, 0-5 g) was added in to 100 ml of inulin extract solution and dissolved with bathing at 40-80°C, and the pH value was measured. Carbon dioxide was introduced into the solution with stirring. When pH of the solution reached the required value, gas supply was immediately stopped. The final solution was filtered, cooled and stored in a refrigeratory at 4°C for analysis. Analysis of chemical components in inulin

extract solution, reduced sugars were determined by 3, 5-dinitrosalicylic acid method using D(-)-Fructose (Mw = 180.16, Fluka) as a reference substance (Miller, 1959). Total sugars were determined by the phenolsulphuric acid method using inulin (Raftiline (r) GR) as (Dubois et al., 1965) a reference substance. pH Value was directly measured with pH meter. $Ca2+$ concentration was determined by colorimetry using calcium carbonate solution (10 μg/ml) as a standard (Liu et al., 2002). Protein content was determined by photometric method using serum protein (0.1 mg/ml) as a standard (Zhu, 2007). Inulin concentration is equal to the concentration difference between total sugars and reduced sugars (Wei et al., 2007).

Inulin loss percentage (%) = 100 × (inulin concentration of extraction solution before processing - inulin concentration of extraction after processing)/ inulin concentration of extraction before processing

Protein reduction efficiency (%) = 100 × (protein concentration before processing - protein content after processing)/ protein concentration before processing

High performance liquid chromatographic analysis (HPLC) of sugar composition, HPLC was applied to analyze sugars in inulin extract solution. Inulin extract solution was diluted 10-fold and filtered through a 0.45 μm fiber membrane prior to HPLC analysis The chromatographic separation was carried out on a Waters amino column (column temperature : 6°C) using a mobile phase composed of a mixture of acetonitrile and water (60 : 40, V/V) at a flow rate of 1.5 ml/min. Analytes were

detected using a Waters 4 1 0 differential refractive index detector with a sensitivity of 64.

Table 3.1 Nutrient compositions of Jerusalem artichoke, Curcuma whit and Sago palm.

Item (%)	Jerusalem artichoke	Curcuma whit	Sago palm
Dry matter	90.25	89.67	87.08
	……%.....		
Crude protein	7.52	7.52	7.09
Organic matter	94.42	94.94	92.91
NDF	13.84	13.44	12.81
ADF	8.51	8.32	7.97
Ether extract	0.97	0.88	0.79
Acid insoluble ash	5.58	5.06	7.09
Inulin (g/100g)[1]	61.68	57.14	60.32
Yields/rai (kg)/crop	2,071[2]	2,362	2,060

[1]Inulin (g/100g dry weight). [2]The interval of Jerusalem artichoke is 3 crop per year, NDE = Neutral detergent fiber, ADF = Acid detergent fiber.

3.4.2 Animals and treatments

Twenty Thai native-Anglo-nubian kids, were selected with regard to sex (10 male, 10 female), and fed colostrum for 5 days before start the experiment. During the experimental period, goat kids received, only milk for days 1-30 (stage 1), thereafter, day 31-75 (stage 2), they were fed concentrate and roughage, and decreased amounts of milk until weaned. During the final stage (stage 3) of the experiment, days 76-90, they were fed only concentrate and roughage. The experimental treatments were as follows :

Treament 1 : control diet

Treament 2 : supplemented with inulin extracted from Jerusalem artichoke at 2% of DM

Treament 3 : supplemented with inulin extracted from Jerusalem artichoke at 4% of DM

Treament 4 : supplemented with commercial inulin at 2% of DM

Treament 5 : supplemented with commercial inulin at 4% of DM

3.4.3 Sample collection and analysis

3.4.3.1 Chemical analysis

Each subsample was dried to determine DM content, then grounded to pass through a 1 mm mesh screen and analyzed for chemical composition. Total N was determined using the Kjeldahl method and crude protein (CP) was calculated by multiplying the N content by 6.25. Ether extract (EE) and ash contents were quantified by AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) determined by the methods described by Goering and van Soest (1970).

3.4.3.2 Complete blood count analysis

Blood collection was performed at the day 0, 28, 50 and 84 according to Kara et al. (2012). Five ml of blood from cephalic vein was divided into three tubes as the following (Weir, 1978). One ml of blood samples was collected into a micro-centrifuge tube with containing EDTA for complete blood count (CBC, RBC, hemoglobin, hematocrit, total white blood cell, neutrophil, basophil, lymphocyte and monocyte) determination. One ml of blood samples was collected into heparinzed polypropylene (PP) tubes for determination of plasma cholesterol. Another 3 ml of

blood samples was collected into heparinzed polypropylene (PP) tubes and placed on ice then centrifuged at 1500 x g for 10 minutes at room temperature for determination of the percentage of phagocyte activity using the method modified from Weir (1978) as follows : 30 µl of *Escherichia coli* (stain ATCC 25922) (1-2 x 107 micro-organism/ml) and 30 µl of serum are combined and incubated at 37°C under continued rotation (4 rev./min) for 0, 15, 30 and 60 min, respectively. Next, cell are fixed with methanol and stranded with Geimsa stain. The percentage of cell that have ingested bacteria is determined from counts of at least 100 phagocytic cell as according to the following formula;

$$\% \text{ of phagocytic activity} = \left[\frac{\text{No. of phagocyte cell have in gested bacteria}}{\text{Total of phagocyte}} \right] \times 100$$

$$\text{Index of phagocyte activity} = \frac{\text{No. of ingested bacteria by phagocyte cell 100 cells}}{100}$$

3.4.3.3 Faecal sampling

Fecal sample was collected on day 0, 14, 28, 42, 56, 70 and 84 in the morning. Total stools of each goat kid were removed from the floor of the pen and kept at 4°C for bacterial enumeration. Microbiological analyses were as follows. Enumeration of mesophilic lactic acid bacteria (ISO 15214, 1998). The plating was performed into MRS medium (de Man, Rogosa and Sharpe. Difco®) from the prepared (10-1 to 10-3) by a duplicated pour plate method. The colonies were counted after incubation at 37°C for 48 hours under anaerobic conditions by double-layer MRS medium (ISO 15214, 1998). The dishes containing 15 to 30 colonies were examined.

The calculation of mesophilic lactic acid bacteria were done as follows. General case. Calculations of APC was done according to the following formula

$$N = \frac{\Sigma C}{[(n1 \times 1) + (n2 \times 0.1)] \times (d)}$$

Where

N = Number of colonies per gram of product

∑c = Sum of all colonies on all plate counted

n1 = Number of plates in first dilution counted

n2 = Number of plates in second dilution counted

d = Dilution from which the first count were obtained

Estimation of low numbers. If the two dishes contained less than 15 colonies, the formula was simplified and only the arithmetical mean was used for calculation;

$$N = \frac{y}{d}$$

y = arithmetical mean of the colonies counted on two dished

d = the dilution factor of the initial suspension

If the two dished did not contain any colonies, the results are to be expressed as follows

- Less than 1/d aerobic bacteria per gram where d is the dilution factor of the initial suspension

Enumeration of *Escherichia coli* (ISO-4831, 1991). The total numbers of *Escherichia coli* was determined by the three tubes most probable number (MPN). Lauryl Sulphate Tryptose broth (LTB) was used as selective enrichment medium. Brilliant Green Lactose Bile Broth (BGLB) and EC-medium were used as confirmation medium. The number of tubes that showed gas formation in the BGLB and EC-confirmation-broth was counted. The probable number of *Escherichia coli* were calculated according to the MPN tables (de Man, J.C. MPN tables. ISO 4831.1991).

Faecal score : Faecal samples was collected from each kid by retrieval from the rectum on the day 0, 14, 28, 42, 56, 70 and 84 at 07.00 h according to Kara et al. (2012). Faecal samples was scored with regard to consistency by the same researcher on all collection days according to the following system : 1 = watery, diarrhoea; 2 = soft, unformed; 3 = soft, formed; 4 = hard, formed and 5 = hard, dry pellets. Faecal pH was measured immediately following the collections. An electronic pH meter (PT-10, Sartorius AG, Goettingen, Germany) fitted with a glass electrode was used to determine faecal pH. Each faecal sample was placed in a 50 ml beaker and diluted 10-fold with distilled water as described by Verlinden et al. (2006). The mixture of faecal sample and distilled water was homogenized and pH was measured.

Fecal samples was collected and weighed during the last 7 days of each period. The fecal samples were collected about 5% of total fresh weight and divided into two parts, the first part being analyzed for DM, the second part kept for chemical analysis at the end of each period.

Concentrates and roughages was sampled daily during the collection period and were composted by period prior to analysis. During the last 7 days

of each period, feed samples was collected every day and divided into two parts, the first part being analyzed for DM, while the second part kept and pooled at the end of each period for chemical analysis. Samples were dried at 60°C and ground (1 mm screen using Cyclotech Mill, Tecator, Sweden) and then analyzed for DM, OM, ash and CP content (AOAC, 1990), NDF, ADF (Goering and Van Soest, 1970).

3.4.3.4 Urine sampling

Total urine was collected on the same day with feces by using plastic container within drop of concentrate sulfuric acid (10%) to avoid nitrogen losing. The urinary samples were collected about 10% of volume and kept in refrigerator and pooled at the end of period to analyze for NH_3-N by Beecher and Whitton, (1965) for determining nitrogen balance.

3.4.3.5 Metabolism trial

Metabolism trial of 7 days collection was conducted for nutrient utilization in goats. The metabolic cages were specially designed with a facility for separate collection of feces and urine. The animals were kept in metabolic cages for 3 days, prior to actual collection of 7 days to acclimatize the animals to the new surroundings. The appropriate aliquots of feed offered, residue left, feces were preserved animal wise for the day for chemical analysis. Body weight of the animals was recorded before and after the metabolism trials. Measurement data of feed offer and residue were obtained.

3.4.4 Statistical analysis

All data was statistically analyzed according to a Randomized Complete Block Design (RCBD). Significant differences between treatments were determined

using Duncan's News Multiple Range Test (DMRT) and Orthogonal contrast analysis by SAS (1996).

3.4.5 Experimental location

The experiment was conducted at Suranaree University of Technology's goat farm, the Chemical analysis was performed at the Center for Scientific and Technological Equipment (CSTE), Buildings 1 and 10, Suranaree University of Technology and microbiology laboratoty of K.M.P. BIOTECH CO., LTD.

3.4.6 Experimental period

The experiment was from November, 2015 to August, 2016.

3.5 Results and discussions

3.5.1 Feed chemical composition

All animals received a diet composing of whole plant silage plus concentrate. The diet was adequate to meet the requirements of crude protein, and dry mater intakes of the goats under the condition of maintenance plus lower activity and 50 g/d weight gain (Nutrient analyses of the feeds were performed according to the Association of Official Analytical Chemists (AOAC, 1995). Contained the main ingredients; ground corn grain, penut meal, repseed meal, coconut meal, wheat bran, rice bram, leucaena, cassava ship, corn gluten meal, sunflower meal, barley, molasses, vegetable oil, mineral and vitamin mix, limestone, salt.) (CP-NUMBER 991-18, as to the concentrate, it contained CP 20.0%, Fat 3.0%, Fiber 9.0% and moisture 13%). The analysis of milk composition it contained of fat 3.63%, protein 3.42%, lactose 4.74%, Ash 0.71% and moisture 87.5%.

Table 3.2 Nutrient compositions of starter concentrate, pangola hay and Jerusalem artichoke on a dry matter basis[1].

Item (%)	Concentrate[2]	Pangola hay	Jerusalem artichoke
Dry matter	89.95	86.21	90.25
……%.....			
Crude protein	20.81	7.35	7.52
Organic matter	92.98	91.54	98.98
NDF	23.14	71.46	13.84
ADF	11.51	43.32	8.39
Ether extract	4.35	2.47	0.97
Acid insoluble ash	7.02	8.46	1.02
Inulin (g/100g)[3]	-	-	61.68

[1]Nutrient analyses of the feeds were performed according to the Association of Official Analytical Chemists (AOAC, 1995). [2]Contained the main ingredients; ground corn grain, peanut meal, rape seed meal, coconut meal, wheat bran, rice bran, leucaena, cassava ship, corn gluten meal, sunflower meal, barley, molasses, vegetable oil, mineral and vitamin mix, limestone, salt. [3]Inulin (g/100g dry weight). NDE = Neutral detergent fiber, ADF = Acid detergent fiber.

3.5.2 Productive performance, faecal score and bacteria population

Final body weight were recorded as; 17.89 kg (T1), 25.40 kg (T2), 17.93 kg (T3), 21.80 kg (T4) and 19.04 kg (T5), results showed that the T2 treatment group, supplementation of inulin extracted from Jerusalem artichoke at 2% of DM, significantly improved body weight ($p<0.05$) when compared to T1, control dirt. Feed intake 75 day records show; 473.53 (T1), 471.95 (T2), 461.22 (T3), 469.36 (T4) and 459.14 (T5) g/day. Treatment groups T1, T2 and T4 showed a significantly higher feed

intake ($p<0.05$) when compared to treatment groups T3 and T5, while feed intake 90 day records show; 594.82 (T1), 620.80 (T2), 593.93 (T3), 599.38 (T4) and 603.84 (T5) g/day, of inulin extracted supplemented 2% of DM (T2) were significantly higher ($p<0.05$), the other groups. However, the increase of feed intake as a result the average daily gains (ADG) 90 day of inulin extracted supplemented 2% of DM (T2) were significantly higher ($p<0.05$) the other groups, is equal 114.17 (T1), 355.00 (T2), 230.84 (T3), 272.50 (T4) and 189.17 (T5) g/day (Table 3.2). And from the orthogonal contrast model study found final body weight, feed intake and ADG of inulin supplemented 2% of DM (T2 and T4) were significantly higher ($p<0.05$). The result of productive performance in our study was supplementation of inulin extract from Jerusalem artichoke at 2% DM can increase of final weight and average daily gain (ADG), which that inulin use has a positive effect on the growth of goat kids. Anyway, the study effects of inulin supplemented in Saanen kids sucking milk by Kara et al. (2012) no differences in body weight. Past of the study of inulin supplementation in calves, found body weight that received inulin in amount 6 g/day/head was higher differential than in 56 day Barbara (2011) and inclusion of inulin replacer of calves to significantly higher live weight gains, better feces consistency (Verdonk and Van Leeuwen, 2004). However, postulated that increase in body weight might be ascribed due to incremented fermentation at the small intestine followed by incremented floe of microbial nitrogen at astronomically immense intestine, stable microflora composition at rumen, minute and astronomically immense intestine of calves (Verdonk et al., 1998).

The results showed that fecal score at 84 day in the inulin supplemented group was significantly increased ($p<0.05$) when compared to T1, control dirt (Table 3.3). And lactic acid bacteria at 56 and 70 day (4.63, 5.98, 6.45, 5.48 and 5.73, 4.60,

5.98, 5.98, 5.65 and 5.53 log_{10}/g in T1, T2, T3, T4 and T5, respectively) was significantly increased ($p<0.05$), and 84 day; 4.73 (T1), 5.53 (T2), 6.48 (T3), 5.88 (T4) and 5.73 (T5) log_{10}/g was highly significantly increased ($p<0.01$) all the group has supplementation of inulin, meanwhile no increase in *Escherichia coli* among dietary treatments. According to studies, it has been found that the capability of inulin supplementation expands sustenance for helpful microorganisms in the body. This builds the number and action of these organisms in the gut. To control the measure of microscopic organisms as a punishment, adhering to demoralize rivalry or catch surface and enhances intestinal microbial equalization inside the exhibit. The driver was removed from enteric pathogens (Ross, 1999; Baurhoo et al., 2007). Kara et al. (2012) examined impacts of inulin supplementation on fecal qualities and soundness of neonatal, milk-fed Saanen kid fecal scores was comparative between gatherings in the present study. Hill et al. (2008), examined impacts of encouraging FOS and MOS in dairy calves and found an unreasonable measure of maturation of fructans by colonic microorganisms can prompt expanded gas development, stomach issues and free defecation. The eating routine of calves supplemented with oligofructose brought about diminished populace of fecal *Escherichia coli* and all out anaerobic microflora while bifidobacteria populace showed expanding patterns (Bunce et al., 1995). This may be credited by gainful impacts brought out through the utilization of prebiotics took after by their aging at hindgut of calves. Joining of oligofructose in the milk replacer of calves brought about enhanced body weight picks up, food transformation productivity with diminishment in the occurrence of the runs and firmer dung (Mul, 1997). In this manner influencing the retention of sustenance. The capacity to absorb into an alternate creature, subsequently, creature sustenance, can be utilized as a part of the developing procedure the development has expanded. (Awad et al., 2008) Meanwhile, include of

microscopic organisms the index (caecum) found to have lower of levels Ammonia (0.673 mg/l) in 25th and disease of *Escherichia coli* (1.3×10^{4}) in the digestive system. In the gathering has supplementing a level of 0.05 percent. There is a pattern of *Escherichia coli* microscopic organisms are declining clearly. The lessening of microorganisms was to be faulted. Such as, Clostridium and Escherichia coli make measure of smelling salts in the intestinal tract and in the blood diminished. Have the impact of hindering cancer-causing agents. Fat amalgamation in the liver subsequently, lipid and cholesterol in the blood diminished (Schijver, 2001; Kaur and Gupta, 2002). Swanson and Fahey (2002) said key part of bifidobacteria and lactobacilli have chemicals disintegrate proteins bunch azoreductase nitroductas nitrate reductase and β-glucuronides low the protein causes these poisons.

3.5.3 Hematological traits and phagocytic activity

The results showed that plasma cholesterol at 84 day were recorded as; 142.00 (T1), 154.25 (T2), 145.25 (T3), 158.75 (T4) and 153.50 (T5) mg/dl, red blood cell (RBC) at 84 day; 7.57 (T1), 9.02 (T2), 8.67 (T3), 8.94 (T4) and 8.86 (T5) 10^{6}/ul and hematocrit at 84 day; 22.33 (T1), 26.53 (T2), 25.00 (T3), 25.18 (T4) and 24.84 (T5) %/ul. Results showed that the treatment group supplementation of inulin significantly increased ($p<0.05$) when compared to control dirt (T1), specifically the suppiementtation of inulin extract from Jerusalem artichoke at 2% (T2). While, the value of white blood cell (WBC), lymphocyte, neutrophils and monocyte were not different ($p>0.05$), among dietary treatments. While, Measurement of phagocyte activity, found the results of this experiment showed that the percentages of phagocyte activity (%PA) and index of phagocyte activity (IPA) the number of engulfed *Escherichia coli* (strain ATCC 25922). It was found that %PA at 28, 42, 56, 70 and 84 day was significantly increased ($p<0.05$), among dietary treatments. And the results showed that

IPA at 42, 56, 70 and 84 day was significantly increased ($p<0.05$), (Table 3.5). The consequences of this trial demonstrated that the rates of phagocyte movement (%PA) action of the goat kids supplemented of inulin extract from Jerusalem artichoke and commercial inulin (Table 3.3-3.6). Mean estimations of each hematological quality were inside reference ranges (Jackson and Cockcroft, 2002) in both CG and EG. Be that as it may, grown-up pooches supplemented with MOS had a higher lymphocyte fixation than control mutts in their study. Davis et al. (2004) watched the expansion in blood lymphocyte fixation and the decline in blood neutrophil focus when pigs were supplemented with 0.3% MOS. The expansion in blood lymphocytes might be valuable in providing protection against pathogens, though the decline in blood neutrophil fixation might be a negative result of sustaining prebiotics as neutrophils assume a key part in the primary line of safeguard against irresistible living beings (Davis et al., 2004). Masanetz et al. (2011) reported no adjustment in the aggregate WBC tally, blood neutrophil, lymphocyte and monocyte centralizations of calves encouraged the eating routine containing 2% inulin. Nonetheless, hemoglobin level in blood of all calves was comparative toward the start of analysis though hemoglobin level in 56 day in calves that got inulin in sum 3 g/day/head was higher than in calves from others bunches. Hematocrit level both at starting and toward the end of analysis in calves from all gatherings was comparable (Babara, 2011). However, these results showed that amid the trial, the goat kid supplemented with 2% of DM inulin from Jerusalem artichoke and 4% of DM commercial inulin had the best %PA. These rates of the trial were likewise more noteworthy than the rates at the test in the present review, the %PA increment as the Lactic acid bacteria number increment. It’s conceivable that there is certain relationship between the quantity of Lactic acid bacteria and %PA. The phagocytosis of microorganisms represents to one of the nonspecific protection

instruments of essential significance for the host. The monocyte/macrophage cell lines, usually alluded to as expert phagocytes, can kill, overwhelm and pulverize particles, including irresistible operators, in this manner displaying a high phagocytic potential (Aderem and Underhill, 1999). In this regard, these cells have been as often as possible assessed for phagocytic and lytic limit against pathogenic microorganisms. Because innate immune replication constitutes the first line of bulwark against invading pathogens. Phagocytosis mechanism is a component of innate immune replication and is, consequently, essential for organism auspice. Phagocytes activity involves kinetics processes in replication to chemotaxis stimulus, adhesion, eradication and abstraction of digested particles. Failures in the phagocytic activity leads to immune deficiencies than can include bacterial and fungal chronic and recurring infections (Lehmann et al., 2000 and Dinauer, 2005). Maitreepawit (2008) reported for the trial the rates of phagocyte movement (%PA) and list of phagocytic (IPA) action of the puppy supplemented with 2% FOS were the best. The consequences of Verlinden et al. (2006) and Masanetz et al. (2011) were in concurrence with those of our study. Contemplates where a safe test is exhibited might be directed to figure out if changes in the centralizations of lymphocyte and neutrophil from blood insusceptible attributes are auxiliary or harmful. Distinctive hematological results on the impacts of inulin or other prebiotic mixes might be acquired for kids confronting an insusceptible test. However, phagocytic activity (PA) of polymorph nuclear and mononuclear blood leukocytes from sheep and goats was quantified utilizing two variants of inert particles ingestion. The percentage of phagocytizing cells reached up to 67.83% in granulocytes and 3.74% in monocytes as resolute by 2-hydroxyethylmethacrylate particles (MSHP) in sheep and goats.

Table 3.3 The effects of inulin supplementation on productive performance of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Initial weight (kg)	4.25	4.00	3.93	3.99	4.13	0.08	0.736	ns	ns	ns
Final weight (kg)	17.89^{a}	25.40^{b}	17.93^{a}	21.80^{ab}	19.04^{a}	0.71	0.030	ns	*	ns
Increase weight (kg)	13.64^{a}	21.40^{b}	14.00^{a}	17.81^{ab}	14.91^{a}	0.75	0.035	ns	*	ns
Feed intake; 30 day (g)	696.67	696.67	696.67	696.67	696.67	0.00	1.000	ns	ns	ns
Feed intake; 75 day (g)	473.53^{a}	471.91^{a}	461.22^{b}	469.36^{a}	459.14^{b}	0.89	0.026	*	ns	*
Feed intake; 90 day (g)	594.82^{a}	620.80^{c}	593.93^{a}	599.38^{ab}	603.84^{b}	1.02	0.012	ns	ns	*
ADG 30 day(g/day)	157.08	190.00	137.92	167.09	137.09	1.54	0.770	ns	ns	ns
ADG 75 day(g/day)	160.28	230.56	142.22	199.17	176.95	0.89	0.133	ns	ns	ns
ADG 90 day(g/day)	114.17^{a}	355.00^{c}	230.84^{ab}	272.50^{bc}	189.17^{ab}	1.97	0.038	*	ns	*

^{a,b,c} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%), ADG = average daily gain, and SEM = standard error of mean.

Table 3.4 The effects of inulin supplementation on fecal score and fecal pH of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Fecal score[1]										
0 day	2.00	2.25	2.00	2.50	2.00	0.15	0.862	ns	ns	ns
14 day	2.25	3.00	2.75	3.25	2.75	0.10	0.148	ns	ns	ns
28 day	3.25	4.00	3.75	4.25	3.50	0.27	0.762	ns	ns	ns
42 day	3.25	4.75	3.50	4.50	2.75	0.28	0.128	ns	ns	ns
56 day	2.75	4.25	3.50	4.50	3.00	0.12	0.061	ns	ns	ns
70 day	3.25	4.75	4.00	4.75	4.00	0.15	0.065	ns	ns	ns
84 day	4.25[a]	5.00[b]	5.00[b]	5.00[b]	5.00[b]	0.05	0.017	*	ns	ns
Fecal pH	7.31	6.82	7.08	6.95	7.13	0.67	0.423	ns	ns	ns

[a,b] Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%). [1]Fecal scoring system; 1 = watery, diarrhoea; 2= soft, unformed; 3 = soft, formed; 4 = hard, formed; and 5 = hard, dry pellets. and SEM = Standard error of mean.

Table 3.5 The effects of inulin supplementation on fecal bacterial populations of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Fecal bacteria population[2]										
***Escherichia coli* (MPN)**										
0 day	5.70	4.85	5.20	4.55	4.93	0.15	0.168	ns	ns	ns
14 day	4.40	4.30	4.38	4.50	3.43	0.43	0.871	ns	ns	ns
28 day	5.10	4.65	5.98	4.60	6.08	0.35	0.360	ns	ns	ns
42 day	5.65	4.85	5.40	4.38	5.03	0.19	0.170	ns	ns	ns
56 day	5.73	4.88	5.88	4.93	5.65	0.15	0.367	ns	ns	ns
70 day	4.80	4.85	5.70	4.58	5.13	0.21	0.644	ns	ns	ns
84 day	5.38	4.65	5.38	4.88	4.83	0.15	0.393	ns	ns	ns

Table 3.5 The effects of inulin supplementation on fecal bacterial populations of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Lactic acid bacteria (log10/g)										
0 day	5.10	5.08	5.18	5.30	5.30	0.10	0.970	ns	ns	ns
14 day	5.58	5.10	6.03	4.23	3.50	0.47	0.447	ns	ns	ns
28 day	4.23	5.50	6.43	6.63	6.45	0.25	0.051	ns	ns	ns
42 day	4.50	6.50	5.65	5.93	5.88	0.15	0.128	ns	ns	ns
56 day	4.63^{a}	5.98^{b}	6.45^{b}	5.48^{ab}	5.73^{b}	0.13	0.037	*	ns	ns
70 day	4.60^{a}	5.98^{b}	5.98^{b}	5.65^{b}	5.53^{b}	0.09	0.022	*	ns	ns
84 day	4.73^{a}	5.53^{b}	6.48^{b}	5.88^{b}	5.73^{b}	0.12	0.001	**	ns	ns
Total bacteria (log_{10}/g)	6.26	5.84	5.34	5.29	6.04	0.12	0.417	ns	ns	ns

^{a,b} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%). [2]Bacterial populations in sterile feces sampled from a subset (n = 10) of healthy kids in each group on day 14, 28, 42, 56, 70 and 84, MPN = most probable number of coliform organisms (*Escherichia coli*) obtain three most probable number table/100 ml, log_{10} = a logarithm to the base 10 and SEM = Standard error of mean.

Table 3.6 The effects of inulin supplementation on plasma cholesterol, hematological traits of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Plasma cholesterol (mg/dl)										
0 day	140.00	139.25	135.75	145.25	148.25	2.17	0.427	ns	ns	ns
28 day	157.50	162.65	169.00	164.50	161.00	5.53	0.824	ns	ns	ns
56 day	145.00	169.75	152.75	141.50	168.00	2.87	0.606	ns	ns	ns
84 day	142.00^{a}	154.25^{b}	145.25^{ab}	158.75^{b}	153.50^{b}	2.10	0.011	*	ns	ns
White blood cell (WBC), 10^4/µl										
0 day	1.67	1.84	1.40	1.81	1.82	0.14	0.214	ns	ns	ns
28 day	1.76	1.83	2.21	1.72	1.82	0.14	0.374	ns	ns	ns
56 day	2.02	1.86	2.12	1.73	1.98	0.12	0.117	ns	ns	ns
84 day	3.37	1.79	2.13	2.23	1.79	0.31	0.258	ns	ns	ns

Table 3.6 The effects of inulin supplementation on plasma cholesterol, hematological traits of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Lymphocytes, %/µl										
0 day	50.25	52.50	51.75	53.50	51.00	1.66	0.742	ns	ns	ns
28 day	52.50	53.25	49.25	56.75	60.25	2.61	0.357	ns	ns	ns
56 day	47.75	54.25	60.50	52.50	55.25	2.12	0.461	ns	ns	ns
84 day	49.50	54.75	57.25	55.25	54.00	1.78	0.447	ns	ns	ns
Neutrophils, %/µl										
0 day	35.25	34.50	35.50	33.25	31.50	0.89	0.457	ns	ns	ns
28 day	43.25	41.50	45.25	42.75	36.75	2.81	0.711	ns	ns	ns
56 day	42.00	40.00	38.00	38.50	40.75	1.52	0.508	ns	ns	ns
84 day	48.50	38.75	40.50	41.50	45.50	0.86	0.312	ns	ns	ns
Monocytes, %/µl										
0 day	1.50	1.75	1.25	2.75	1.25	0.27	0.274	ns	ns	ns
28 day	2.25	2.00	1.75	2.00	2.50	0.32	0.210	ns	ns	ns
56 day	3.35	4.25	4.75	2.25	2.75	0.43	0.146	ns	ns	ns
84 day	1.50	2.00	2.25	1.50	2.00	0.19	0.082	ns	ns	ns

Table 3.6 The effects of inulin supplementation on plasma cholesterol, hematological traits of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Eosinophils, %/µl										
0 day	1.14	1.47	1.53	1.26	1.19	0.08	0.791	ns	ns	ns
28 day	3.39	3.88	3.27	2.94	3.04	0.11	0.457	ns	ns	ns
56 day	4.23	4.18	3.99	4.26	4.51	0.15	0.382	ns	ns	ns
84 day	4.36	4.00	3.21	3.71	5.04	0.74	0.376	ns	ns	ns
Red blood cell (RBC), 10^6/µl										
0 day	8.32	8.61	8.31	7.57	7.81	0.20	0.114	ns	ns	ns
28 day	8.24	8.35	8.07	7.69	7.87	0.27	0.618	ns	ns	ns
56 day	8.09	7.89	7.75	8.40	8.01	0.21	0.339	ns	ns	ns
84 day	7.57^{a}	9.02^{b}	8.67^{ab}	8.94^{b}	8.86^{ab}	0.18	0.012	*	ns	ns

Table 3.6 The effects of inulin supplementation on plasma cholesterol, hematological traits of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Hemoglobin, g/dl										
0 day	7.70	7.89	7.80	7.03	7.08	0.16	0.743	ns	ns	ns
28 day	8.10	8.78	8.08	8.43	7.60	0.23	0.189	ns	ns	ns
56 day	8.28	8.18	8.18	8.60	8.45	0.30	0.274	ns	ns	ns
84 day	8.56	9.33	8.63	9.20	9.45	0.29	0.344	ns	ns	ns
Hematocrit, %/µl										
0 day	19.93	21.15	20.45	20.01	19.25	0.31	0.705	ns	ns	ns
28 day	21.73	23.29	20.40	21.23	21.30	0.47	0.451	ns	ns	ns
56 day	21.88	22.90	21.30	22.18	22.68	0.62	0.224	ns	ns	ns
84 day	22.33^{a}	26.53^{b}	25.00^{ab}	25.18^{ab}	24.84^{ab}	0.46	0.007	**	ns	ns

^{a,b} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant ,control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) and SEM = standard error of mean.

Table 3.7 The effects of inulin supplementation on percentages of phagocyte activity (%PA) and index of phagocyte activity (IPA) of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Percentages of phagocyte activity (%PA)										
0 day	29.07	28.71	28.65	28.58	29.26	0.14	0.128	ns	ns	ns
14 day	29.73	30.18	30.01	30.13	29.94	0.05	0.076	ns	ns	ns
28 day	30.03^{a}	30.36^{b}	30.20^{ab}	30.34^{b}	30.21^{ab}	0.03	0.003	**	ns	**
42 day	30.26^{a}	31.94^{b}	31.28^{b}	31.90^{b}	31.19^{b}	0.10	0.012	*	ns	*
56 day	29.29^{a}	31.18^{c}	30.37^{b}	31.11^{bc}	30.43^{b}	0.10	0.010	*	ns	*
70 day	29.23^{a}	30.85^{b}	30.08^{ab}	30.93^{b}	29.61^{a}	0.14	0.015	*	ns	*
84 day	29.25^{a}	30.44^{bc}	29.98^{ab}	31.10^{c}	29.80^{ab}	0.14	0.007	**	ns	**

Table 3.7 The effects of inulin supplementation on percentages of phagocyte activity (%PA) and index of phagocyte activity (IPA) of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Index of phagocyte activity (IPA)										
0 day	4.20	4.24	4.25	4.43	4.31	0.02	0.278	ns	ns	ns
14 day	4.43	4.57	4.22	4.53	4.49	0.05	0.058	ns	ns	ns
28 day	4.33	4.59	4.43	4.46	4.47	0.05	0.845	ns	ns	ns
42 day	4.25^{a}	4.61^{b}	4.48^{b}	4.54^{b}	4.48^{b}	0.03	0.020	*	ns	ns
56 day	4.05^{a}	4.62^{b}	4.30^{ab}	4.70^{b}	4.47^{b}	0.06	0.049	*	ns	ns
70 day	3.93^{a}	4.43^{b}	4.43^{b}	4.63^{b}	4.41^{b}	0.05	0.038	*	ns	ns
84 day	3.65^{a}	4.27^{b}	4.10^{ab}	4.39^{b}	4.10^{ab}	0.02	0.009	**	ns	*

^{a,b,c} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) and SEM = standard error of mean.

3.5.4 Dry matter intake, body weight change, nutrient digestibility, nitrogen utilization, ruminal ammonia, blood urea nitrogen and volatile fatty acid proportion

The results showed that nutrient intake (crude protein) were recorded as; 55.52 (T1), 57.00 (T2), 55.38 (T3), 57.15 (T4) and 55.62 (5) g/day, was significantly increased ($p<0.05$), specifically the inulin extracted from Jerusalem artichoke at 2% of DM (T2) and commercial inulin at 2% of DM (T4), and ether extract were recorded as; 6.96 (T1), 6.22 (T2), 6.63 (T3), 6.23 (T4) and 6.59 (T5) g/day, results showed that the all group supplementation of inulin was highly significantly decrease ($p<0.01$). Percentages of appearance digestibility (organic matter, ether extract, neutral detergent fiber and acid detergent fiber) was significantly increased ($p<0.05$), specifically the inulin extracted from Jerusalem artichoke at 2% of DM (T2) and commercial inulin at 2% of DM (T4). However, it was found that the level of supplementation affects on percentages of appearance digestibility. Meanwhile, no increase in nitrogen utilization, ruminal pH, ruminal ammonia nitrogen (NH_3-N) and blood urea nitrogen (BUN) among dietary treatments. Results showed that the level of supplementation affects on urine nitrogen. While, Santoso et al. (2003) reported the dry matter intake, nutrient digestibility is as such not affected by prebiotic supplementation but showed higher nitrogen retention owing to increased microbial protein synthesis in rumen. And the study results which this shows the efficiency in generating better living this is due to the efficient digestion and nutrient utilization, may be due to the inulin effect on the increase of gastric microbes this results in improved digestion performance. Paengkoum, (2012) reported microorganisms in rumen of small ruminant it acts to digest the feed that the animal eats into, and the efficiency of microbial synthesis in

ruminants it depends on the whole protein and carbohydrate and in ruminants there are microbes that can digest cellulose hemicellulose pulp to obtain the sugar, microorganisms can be utilized and about 60% of all digestible carbohydrates it is synthesized into volatile fatty acids in the rumen include acidic acid propionic acid and butyric acid, all the rumen hemicellulolytic bacteria are capable to utilize xylooligosaccharides as growth substrate (Cota and Whitefield, 1998).

Total volatile fatty acid 3 h post feeding were recorded as; 91.51 (T1), 95.99 (T2), 93.24 (T3), 95.32 (T4) and 94.02 (T5) mM/L, and 6 h post feeding were recorded as; 89.66 (T1) 93.06 (T2), 90.07 (T3), 93.01 (T4) and 92.01 (T5) mM/L, results showed that the T2 and T4 treatment proup, supplementation of inulin at 2% of DM, was significantly increase ($p<0.05$). Volatile fatty acid proportion (acitic acid; C_2) 6 h post feeding were recorded as; 61.42 (T1), 58.07 (T2), 59.06 (T3), 58.06 (T4) and 60.32 (T5) %mol, results showed that the all group supplementation of inulin was significantly decrease ($p<0.05$). Propionic acid (C_3) at 3 h post feeding; 24.72 (T1), 27.69 (T2), 25.59 (T3), 27.37 (T4) and 26.81 (T5) %mol, result showed that the T2, T4 and T5 treatment group, was significantly increase ($p<0.05$). Butyric acid (C_4) at 3 h post feeding; 15.19 (T1), 14.79 (T2), 15.13 (T3), 12.51 (T4) and 14.22 (T5) %mol, result showed that the T2, T4 and T5 treatment group, was significantly decrease ($p<0.05$). While, ratios of $C_2 : C_3$ at 6 h post feeding were recorded as; 2.52 (T1), 2.17 (T2), 2.34 (T3), 2.12 (T4) and 2.31 (T5), was significantly decrease ($p<0.05$) all group supplementation of inulin. And methane (CH_4) at 3 h post feeding; 26.32 (T1), 24.18 (T2), 25.69 (T3), 24.54 (T4) and 24.86 (T5), results showed that the T2, T4 and T5 tretment group, was significantly decrease ($p<0.05$). While, some in vitro studies ascertained that inulin increased the VFA productions at a higher extent than pectin and

arabinoxylan (Marounek et al., 1999). Umucalilar et al., (2010) reported the total VFA concentration quadratically decreased with increasing forage proportion and were associated with the increase of acetate proportion and the decreases of butyrate, because of its greater solubility and increased total VFA concentration in the rumen in response to inulin addition are in agreement with literature data focusing on colon fermentation (Rosendo et al., 2003; Dijkerman et al., 1997). And the inulin effect on the VFA production was dependent of the forage/ concentrate ratio of the mixture but this fructan exhibited no significant effect by itself on the overall and specific ruminal VFA formation (Umucalilar et al., 2010). However, the study result there was no significant difference in ammonia concentrations. While, Samanta et al. (2013) reported the effect of prebiotic consumption in ruminant cause rumen ammonia nitrogen concentration was slightly lower. It is expected that inulin could be the part of diets in both ruminants for enabling modulation of gut microflora *vis a vis* animals productivity in ecological ways and our data was utilizable to determine the dose and timing of inulin supplementation in further studies investigating the effects of inulin on the parameters associated with performance and immune modulation or health status in kids and other adolescent ruminants.

Table 3.8 The effects of inulin supplementation on nutrient digestibility and nitrogen utilization of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Nutrient intake, g/day										
Ogranic matter	394.53	403.76	391.09	403.96	392.35	1.14	0.052	ns	ns	ns
Crude protein	55.52^{a}	57.00^{b}	55.38^{a}	57.15^{b}	55.62^{a}	0.13	0.019	*	ns	*
Ether extract	6.96^{a}	6.22^{c}	6.63^{b}	6.23^{c}	6.59^{b}	0.02	0.001	**	**	**
Neutral detergent fiber	219.67	224.14	216.47	223.79	216.94	0.75	0.104	ns	ns	ns
Acid detergent fiber	128.67	131.24	126.70	131.01	126.96	0.45	0.0110	ns	ns	ns
Appearance digestibility, %										
Ogranic matter	69.63^{a}	76.21^{c}	71.87^{b}	76.12^{c}	72.58^{b}	0.22	0.011	*	ns	*
Crude protein	77.79	78.54	77.14	75.36	77.61	0.48	0.131	ns	ns	ns
Ether extract	67.83^{a}	78.93^{b}	69.90^{a}	78.18^{b}	79.89^{b}	0.27	0.019	*	ns	*
Neutral detergent fiber	63.23^{a}	70.57^{c}	66.06^{b}	70.94^{c}	66.19^{b}	0.25	0.038	*	ns	*
Acid detergent fiber	55.34^{a}	60.95^{b}	55.11^{a}	61.11^{b}	55.37^{a}	0.35	0.025	*	ns	*

Table 3.8 The effects of inulin supplementation on nutrient digestibility and nitrogen utilization of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Nitrogen utilization (g/day)										
Nitrogen intake	12.16	12.12	11.79	12.00	11.81	0.02	0.078	ns	ns	ns
Fecal nitrogen	1.96	1.93	2.03	2.25	1.99	0.06	0.067	ns	ns	ns
Urinal nitrogen	2.89^{a}	3.11^{b}	2.90^{a}	2.93^{ab}	2.89^{ab}	0.04	0.025	*	ns	*
N absorption (g)	6.92	7.19	6.83	6.90	6.91	0.05	0.633	ns	ns	ns
N retention (g)	4.03	4.08	3.94	3.97	4.02	0.04	0.130	ns	ns	ns
N absorption (%)	77.90	78.81	77.15	75.49	77.61	0.63	0.171	ns	ns	ns
N retention (%)	45.36	44.74	44.44	43.40	45.19	0.38	0.765	ns	ns	ns

^{a,b,c} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) and SEM = standard error of mean.

Table 3.9 The effects of inulin supplementation on ruminal pH, ruminal ammonia nitrogen and blood urea nitrogen of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Ruminal pH										
0 h post feeding	6.97	6.91	7.03	7.01	7.00	0.02	0.719	ns	ns	ns
3 h post feeding	7.00	6.95	6.98	6.91	6.96	0.06	0.411	ns	ns	ns
6 h post feeding	7.02	6.85	6.99	6.92	6.98	0.04	0.574	ns	ns	ns
Ruminal NH_3-N (mg/dl)										
0 h post feeding	13.87	14.36	13.94	13.87	13.66	0.05	0.428	ns	ns	ns
3 h post feeding	17.86	16.18	17.23	16.53	16.95	0.04	0.801	ns	ns	ns
6 h post feeding	17.30	15.13	17.09	16.11	16.60	0.63	0.136	ns	ns	ns
Blood urea nitrogen (BUN) (mg/dl)										
0 h post feeding	14.50	16.75	14.75	15.00	14.75	0.50	0.452	ns	ns	ns
3 h post feeding	14.00	16.00	16.00	15.00	15.50	0.57	0.083	ns	ns	ns
6 h post feeding	14.75	15.75	15.50	16.00	14.50	0.43	0.109	ns	ns	ns

ns = non-significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) NH_3-N = ammonia nitrogen, BUN = blood urea nitrogen and SEM = Standard error of mean.

Table 3.10 The effects of inulin supplementation on volatile fatty acid proportion of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Total volatile fatty acid (mM/L)										
0 h post feeding	91.59	93.57	92.58	93.66	92.92	0.40	0.209	ns	ns	ns
3 h post feeding	91.51^{a}	95.99^{c}	93.24^{ab}	95.32^{c}	94.02^{ab}	0.27	0.031	*	ns	*
6 h post feeding	89.66^{a}	93.06^{b}	90.07^{ab}	93.01^{b}	92.01^{ab}	0.47	0.030	*	ns	ns
Volatile fatty acid proportion (%mol)										
Acitic acid (C_2)										
0 h post feeding	60.54	58.38	59.30	59.60	59.62	0.56	0.077	ns	ns	ns
3 h post feeding	60.10	57.52	59.28	60.14	58.98	0.23	0.475	ns	ns	ns
6 h post feeding	61.42^{a}	58.07^{c}	59.06^{c}	58.06^{c}	60.32^{b}	0.16	0.006	**	ns	**
Propionic acid (C_3)										
0 h post feeding	25.93	27.19	26.04	23.11	25.98	0.32	0.129	ns	ns	ns
3 h post feeding	24.72^{a}	27.69^{b}	25.59^{a}	27.37^{b}	26.81^{b}	0.13	0.035	*	ns	*
6 h post feeding	24.32	26.83	25.29	27.58	26.20	0.42	0.134	ns	ns	ns

Table 3.10 The effects of inulin supplementation on volatile fatty acid proportion of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Butyric acid (C_4)										
0 h post feeding	13.54	12.43	14.66	13.30	14.40	0.46	0.520	ns	ns	ns
3 h post feeding	15.19^{a}	14.79^{b}	15.13^{a}	12.51^{c}	14.22^{bc}	0.27	0.005	**	*	*
6 h post feeding	14.26	15.10	15.66	14.32	13.47	0.39	0.623	ns	ns	ns
Ratios of C_2 : C_3										
0 h post feeding	2.35^{a}	2.01^{b}	2.28^{ab}	2.20^{ab}	2.30^{ab}	0.04	0.041	ns	*	ns
3 h post feeding	2.44^{a}	2.08^{b}	2.32^{a}	2.20^{ab}	2.20^{ab}	0.02	0.017	*	ns	*
6 h post feeding	2.52^{a}	2.17^{b}	2.34^{ab}	2.12^{b}	2.31^{ab}	0.04	0.013	*	ns	*
Methene (CH_4)										
0 h post feeding	25.53	23.22	25.39	24.69	25.45	0.24	0.115	ns	ns	ns
3 h post feeding	26.32^{a}	24.18^{b}	25.69^{a}	24.54^{b}	24.86^{b}	0.12	0.035	*	ns	*
6 h post feeding	26.66	24.79	25.89	24.28	25.33	0.28	0.101	ns	ns	ns

^{a,b,c} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) and SEM = standard error of mean.

3.6 Conclusions

The impact of inulin in milk is beneficial to productive performance, hematological attributes of goat kids, resulting in production performance, fecal score. Specifically, inulin extracted from Jerusalem artichoke, supplemented at 2% of DM, has proven to enhance feed consumption, average daily gains and final body weights. These improvements are likely to influence microbial populations, phagocyte action, nutrient digestibility, nitrogen utilization and volatile fatty acid proportion as will. Be that as it may, various possible mechanisms of action probiotics have been suggested among which are the stimulation the production of antimicrobial substances, competition for adhesion to epithelial cells and stimulation of the immune system of affects the goat's good health.

3.7 References

Aderem, A., and Underhill, D.M. (1999). Mechanisms of phagocytosis in macrophages. **Annual Review of Immunology**. 17: 593-623.

AOAC. (1995). Official Method of Analysis. 16th ed. Association of Official Analytical Chemist, Washington, DC.

Awad, W., Ghareeb, K., and Böhm, J. (2008). Intestinal structure and function of Broiler chickens on diets supplemented with a symbiotic containing *Enterococcus* faecium and oligosaccharides. **International Journal of Molecular Sciences**. 9: 2205-2216.

Babara, K. (2011). Effect of mannan-oligosaccharides, inulin and yeas nucleotides added to calf milk replacers on rumen microflora, level of serum

immunoglobulin and health condition of calves. **Electronic Journal of Polish Agricultural Universities**. 14(2): 18.

Baurhoo, B., Letellier, A., Zhao, X., and Ruiz-Feria, C. A. (2007). Cecal populations of *Lactobacilli* and *Bifidobacteria* and *Escherichia coli* after in vivo *Escherichia coli* challenge in birds fed diets with purified lignin or mannanoligo-saccharides. **Journal of Poultry Science**. 86: 2509-2516.

Beecher, G.R., and Whitton, B.K. (1978). Ammonia determination: Modification and interfering compounds. **Analytical Biochemistry**. 36: 243-246.

Benda, V., and Hoiipes, J. (1991). Phagocytic Activity of Leukocytes in Sheep and Goats. **Acta veterinaria Brno**. 60: 149-152.

Bunce, T.J., Howard, M.D. Kerley, M.S., and Allece, G.I. (1995). Feeding fructooligosaccharides to calves increased Bifidobacterium and decreased *Escherichia coli*. **Journal of Animal Science**. 73: 281.

Cota, M.A., and Whitefield, T.R. (1998). Xylooligosaccharides utilization by ruminal anaerobic bacterium *Selemonas ruminantium*. **Current Microbiology**. 36: 183-189.

Crocker, C. L. (1967). Rapid determination of urea nitrogen in serum or plasma without deproteinization. **The American Journal of Medical Technology**. 33: 361-365.

Davis, M.E., Maxwell, C.V., Erf, G.F., Brown, D.C., and Wistuba, T.J. (2004). Dietary supplementation with phosphorylated mannans improves growth response and modulates immune function of weanling pigs. **Journal of Animal Science**. 82: 1882-1891.

Dijkerman, R., Ledeboer, J., Op Den Camp, H.J.M., Prins, R.A., and Vanderdrift, C. (2002). The anaerobic fungus Neocallimastix sp. Strain L2: growth and production of hemicellulolytic enzymes on a range of carbohydrate substrates. **Current Microbiology**. 34: 91-96.

Dinauer, M.C. (2005). Chronic Granulomatous Disease and other disorders of phagocyte function. **Hematology**. (1): 89-95.

Dobre, T., Stroescu, M., Stoica, A., Draghici, E., and Antohe, N. (2008). Inulin extraction and encapsulation. **Chemical Bullrtin of Politehnica University of Timisoara**. 35(67): 215-217.

Dubois, M., Giles, K.A., Hamilton, J.K., Rebers, P.A., and Smith, F. (1956). Colorimetric method for determination of sugar and related substances. **Journal of Analytical Chemistry**. 28: 350-356.

Flickinger, E.A., Van Loo, J., and Fahey, G.C. (2003). Nutritional responses to the presence of inulin and oligofructose in the diets of domesticated animals; a review. **Critical Reviews in Food Science and Nutrition**. 43: 19-60.

Gibson, G.R., and Roberfroid, B. (1995). Dietary modulation of the human colonic microbiota; Introducing the concept of prebiotic. **Journal of Nutrition**. 125: 1401-1412.

Hill, J.C., Dunn, K.M., Lewis, M.R., Mullis, C., Main, J., and Foster, N.E. (2008). A primary care back pain screening tool; identifying patient subgroups for initial treatment. **Arthritis and Rheumatology**. 59(5): 632-641.

ISO-4831. (1991). Microbiology-general guidance for enumeration of presumptive *Escherichia coli*-most probable number technique. 70-83.

ISO-15214. (1998). Microbiology of food animal feeding stuffs-horizontal method for the enumeration of mesophilic lactic acid bacteria-colony-count technique at 30 ºC. Microbiology. 23-41.

Jackson, P.G.G., and Cockcroft, P. D. (2002). Normal physiological values. In **Clinical examination of farm animals**. Wiley-Blackwell, Oxford, UK. 301 p.

Kara, C., Orman, A., Gencoglu, H., Kovanlıkaya, A., Meral, Y., Cetin, I., Yıbar,A., Kasap, S., Turkmen, I., and Deniz, G. (2012). Effects of inulin supplementation on selected fecal characteristics and health of neonatal Saanen kids sucking milk from their dams. **Animal**. 6(12): 1947-1954.

Kaur, N., and Gupta, A.K. (2002). Applications of inulin and oligofructose in health and nutrition. **Journal of Biological Science**. 27(7): 703-714.

Lehmann, A.K., Sornes, S., and Halstensen, A. (2000). Phagocytosis: measurement by flow cytometry. **Journal of Immunological Methods**. 243(1-2): 229-242.

Liu, S.P., Yang, L.X., and Liu, Z.F. (2002). A Selective photometric method for determining the microamounts of calcium. **Journal of Modern Scientific Instruments**.1: 54-56.

Maitreepawit, S. (2008). The effects of fructooligosaccharide supplementation on gut microflora, nutrient digestibility, plasma cholesterol and phagocyte activity in adult dogs. A thesis submitted in partial fulfillment of the requirements for the degree of master of scienceprogram in animal nutrition department of animal husbandry, faculty of veterinary science, chulalongkorn university. 53 p.

Marounek, M., Suchorska, O., and Savka, O. (1999). Effect of substrate and feed antibiotics on *in vitro* production of volatile fatty acid and methane in caecal contents of chickens. **Animal Feed Science and Technology**. 80: 223-230.

Masanetz, S., Preißinger, W., Meyer, H. H.D., and Pfaffl, M.W. (2011). Effects of the prebiotics inulin and lactulose on intestinal immunology and hematology of preruminant calves. **Animal**. 5(7): 1099-1106.

Miller, G.L. (1959). Use of dinitrosalicylic acid reagent for determination of reducing sugar. **Journal of Analytical Chemistry**. 31: 420-428.

Moss, A.R., Jouany, J.P. and Newbold, J. (2000). Methane production by ruminants: its contribution to global warming. **Annales de Zootechnie**. 49: 231-253.

Mul, A.J. (1997). Application of oligofructose in animal feeds. In **Proceedings of International Symposium Non-Digestible Oligosaccharides; Healthy Food for colon?** (pp 106). The Netherlands; Wageningen.

Paengkoum, P. (2012). Small ruminant nutrition. School of animal production technology, Institute of agricultural technology, Suranaree university of technology. 275 p.

Rosendo, O., Hall, M.B., Staples, C., and Bates, D. (2003). The effect of different neutral detergent-soluble polysaccharides in digestive cynetics *in vitro* of neutral detergent forage fiber and the synthesis of microbial protein. **Revista Cientifica-Facultad de Ciencias Veterinarias**. 13: 18-27.

Ross, G.C. (1999). Prebiotic. In W.T. Geral (ed.). **Prebiotics a Critical Review** (pp. 141-156). Wymondham; Horizon Scientific Press.

Samuel, M., Sagathewan, S., Thomus, J. and Mathen, G. (1997). An HPLC method for estimation of volatile fatty acids of rumen fluid. **Indian Journal of Animal Science**. 67: 805-807.

Statistical Analysis System. (1996). SAS/STAT User's Guide: Statistics, Version 6.12 edition. SAS Inc., Cary, NC, USA.

Swanson, K.S., and Fahey, G.C. (2002). Prebiotics in companion animal nutrition. In T.P. Lyons and K.A. Jacques (eds.). **Biotechnology in the feed industry. Proc. Alltech's 18th Ann. Symp** (pp 461-473). Loughborough, U.K.; Nottingham University Press.

Tapingkae, W. (2014). Alternatives to the use of antibiotics as growth promoters for livestock animals. **Agricultueral Journal**. 30(2): 201-212.

Umucalilar, H.D., Gülşen, N., Hayirli, A., and Alataş, M.S. (2010). Potential role of inulin in rumen fermentation. **Revue de Medecine Veterinaire**. 161(1): 3-9.

Verdonk, J.M.A.J., Beelan, G.M., Jansman, A.J.M., and Huismam, J. (1998). Effect of soya carbohydrate fraction on the ileal digestibility and endogenous flow of nitrogen in veal calves. In A.J.M. Jansman, G.D. Hill, J. Huisman and A.F.B. Vander Poel (eds.). **Recent Advances of Research in Antinutritional Factors in Legume Seeds** (pp 341-343). The Netharlands; Wageningen.

Verdonk, J.M.A.J., and Van Leeuwen, P. (2004). The application of inulin type fructans in diets for velves and broilers. In **Inulin and Oligofructose Feed Good Factors for Health and Wellbeing. 4th Orafti Research Conference**. Paris.

Verlinden, A., Hesta, M., Hermans, J.M., and Janssens, G.P.J. (2006). The effects of inulin supplementation of diets with or without hydrolyzed protein sources on digestibility, fecal characteristics, hematology, and immunoglobulins in dogs. **British Journal of Nutrition**. 96: 936-944.

Younes, H., Garleb, K., Behr, S., Rémésy, C., and Demigné, C. (1995). Fermentable fibers or oligosaccharides reduce urinary nitrogen excretion by increasing urea disposal in the rat cecum. **Journal of Nutrition**. 125: 1010-1016.

Wei, L.Y., Wang, J.H., Zheng, X.D., Teng, D., Yang, Y.L., Cai, C.G., Feng, T.H., and Zhang, F. (2007). Studies on the extracting technical conditions of inulin from Jerusalem artichoke tubers. **Journal of Food Engineering**. 79(3): 1087-1093.

Weir, D.M. (1978). Handbook of experimental immunology. Vol.2 cellular immunology. 3rd Oxford; Blackwell scientific publication. 46.1-46.21.

Zhu, M. (2007). Isolation and property study on the polysaccharide of herba asari. Changchun: Northeast Normal University.

CHAPTER IV

EXPERIMENT II

EFFECT OF INULIN IN CREEP FEED ON PRODUCTIVE PERFORMANCE, HEMATOLOGICAL TRAITS AND NUTRIEN DIGESTIBILITY OF GOAT KIDS

4.1 Abstract

This research investigated inulin supplementation effects on productive performance of goat kids. Twenty goat kids (Thai native × anglo-nubian) during the experimental period. Were grouped with regard to sex and were fed colostrum for 5 days before start the experiment. During the experimental period, the goats were given only milk on days 1-30, thereafter, days 31-75, they were fed with concentrate and roughage, and decreased amount of milk until weaned. There were five dietary treatments groups; control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2) and 4% of DM (T3), and commercial inulin supplemented 2% of DM (T4) and 4% of DM (T5) of goat kid, respectively. The five treatments were arranged in a randomized complete block design. The results showed that final body weight, feed intake and average daily gains were significantly different ($p<0.05$), specifically the supplementation of inulin from Jerusalem artichoke at 2% of DM (T2). Moreover, Lactic acid bacteria were significantly different ($p<0.05$) among

dietary treatments. In addition, percentages of phagocyte activity (%PA) was found that at 42 and 70 day was significantly increased ($p<0.05$), specifically the inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2) and commercial inulin supplemented 2% of DM (T4). Furthermore, using inulin at four supplement levels increased percentages of phagocyte activity (%PA) at 70 and 84 day, among dietary treatments. Percentages of appearance digestibility (OM, EE, NDF and ADF) was highly significantly increased ($p<0.01$), specifically the inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2) and commercial inulin supplemented 2% of DM (T4), and volatile fatty acid proportion found propionic acid was highly significantly increase ($p<0.01$). While, acitic acid and methane was highly significantly decrease ($p<0.01$). However, sex was not found to affect experimental.

Keywords : Goat kid, Inulin, Productive performance, Hematological traits, Ruminant and Prebiotic.

4.2 Introduction

Prebiotics are an essential part of maintaining overall gastrointestinal health through stimulation of bacterial growth, inhibition of pathogens, and nourishment of probiotics. Inulin is considered to be an extremely important prebiotic by development of microscopic organisms, acidophilus, bifidus and faecium, and by providing the digestive system with fruto-oligosaccharides (FOS).

Inulin is a complex sugar particle that has valuable impacts as a sustenance fixing. Inulin is thought to be nourishment fixing. Inulin is a polysaccharide comprises fructose joined by a beta 2, 1 glycosidic bond containing little measures of glucose (one unit of glucose and ≤ 60 fructose units). Inulin is a capacity polysaccharide comprising

of a chain of fructose particles. Inulin is neither processed nor ingested in small digestive system however it is selectively and immediately ages by microscopic organisms in further components of wholesome tract animating multiplication of lactobacillus, principally Bifidobacterium. Inulin is for the most part popularized as a powder, which accommodates less authoritatively mandating control, conveyance, stockpiling and utilization. The most every now and again utilized technique to get this type of inulin is the drying of a fluid concentrate by splash drying, which requires a plethora of vitality (Dobre et al., 2008). Bifidogenic activity component depends on particular aging of fructans by Bifidobacteria synthesing beta-fructosidasis, protein disintegrating beta 2,1 glycosidic bonds in inulin and oligofructosis. Change of bacterial microflora in digestive system, comprised in dismaying number of unsafe microscopic organisms is optically canvassed as a consequence of bifidogenic impact. Their multiplication is repressed by Bifidobacteria that engender short-chain unsaturated fats (SCFA) and lower pH of digestive system chyme the same achieve uncongenial conditions for pathogens. In integration Bifidobacteria rival pathogens for annexation's place in intestinal epithelium, for supplements and distribute anti-microbial substances, alleged bacteriocins and hydrogen peroxide Among species that multiplication is daunted by different trains of Bifidobacteria are had a place with among others *Escherichia coli*, Salmonella, Shigella, Campylobacter jejuni and Clostridium perfirgens. Amid bacterial aging of fructans short-chain unsaturated fats are delivered, particularly acidic, propionic, lactic and butyric corrosive (Gibson and Roberfroid, 1995). These acids show advantageous impact on digestion system, sustain intestinal cells, lower pH of intestinal chyme and extend intestinal villuses and in addition increment number of epithelial cells in particular villus (Barbara, 2011).

Despite the fact that inulin is available in more than 30,000 vegetable items, chicory is the main vegetable utilized for the mechanical engenderment of inulin. Jerusalem artichoke tubers with 14-19% of inulin can be a consequential wellspring of inulin as well. Jerusalem artichokes contain large concentrations of prebiotics, specifically inulin. Inulins retrieved from Jerusalem artichokes have more prominent natural movement. And Jerusalem artichoke has shown to increase Bifidobacteria and lactobacilli concentration in the intestinal tract and decrease pathogens such as, clostridium and Escherichia coli (Younes et al., 1995; Kaur and Gupta, 2002). In the event that utilization prebiotic with probiotic or we call symbiotic, the probiotic will flourish than include probiotic since they are sub serve together. Furthermore, more probiotic go to intestinal (Tapingkae, 2014). This research has purpose for study usage inulin extracted from Jerusalem artichoke and commercial inulin for increase the productive performance and immune modulation of goat kids.

4.3 Objective

The objective of this experiment was to investigate the effects of inulin extract in milk replacer on productive performance and immune modulation of goat kid.

4.4 Materials and methods

4.4.1 Animals and treatments

Twenty goat kids, (Thai native anglo-nubian), were selected with regard to sex (10 male, 10 female), and fed colostrum for 5 days before start the experiment. During the experimental period, goat kids received, only milk for days 1-30 (stage 1), thereafter, day 31-75 (stage 2), they were fed concentrate and roughage, and decreased

amounts of milk until weaned. During the final stage (stage 3) of the experiment, days 76-90, they were fed only concentrate and roughage. The experimental treatments were as follows :

Treament 1 : control diet

Treament 2 : supplemented with inulin extracted from Jerusalem artichoke at 2% of DM

Treament 3 : supplemented with inulin extracted from Jerusalem artichoke at 4% of DM

Treament 4 : supplemented with commercial inulin at 2% of DM

Treament 5 : supplemented with commercial inulin at 4% of DM

4.4.2 Sample collection and analysis

4.4.2.1 Chemical analysis

Each subsample was dried to determine DM content, then grounded to pass through a 1 mm mesh screen and analyzed for chemical composition. Total N was determined using the Kjeldahl method and crude protein (CP) was calculated by multiplying the N content by 6.25. Ether extract (EE) and ash contents were quantified by AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) determined by the methods described by Goering and van Soest (1970).

4.4.2.2 Complete blood count analysis

Blood collection was performed at the day 0, 28, 50 and 84 according to Kara et al. (2012). Five ml of blood from cephalic vein was divided into three tubes as the following (Weir, 1978). One ml of blood samples was collected into a micro-centrifuge tube with containing EDTA for complete blood count (CBC, RBC,

hemoglobin, hematocrit, total white blood cell, neutrophil, basophil, lymphocyte and monocyte) determination. One ml of blood samples was collected into heparinzed polypropylene (PP) tubes for determination of plasma cholesterol. Another 3 ml of blood samples was collected into heparinzed polypropylene (PP) tubes and placed on ice then centrifuged at 1500 x g for 10 minutes at room temperature for determination of the percentage of phagocyte activity using the method modified from Weir (1978) as follows : 30 µl of *Escherichia coli* (stain ATCC 25922) (1-2 x 107 micro-organism/ml) and 30 µl of serum are combined and incubated at 37°C under continued rotation (4 rev./min) for 0, 15, 30 and 60 min, respectively. Next, cell are fixed with methanol and stranded with Geimsa stain. The percentage of cell that have ingested bacteria is determined from counts of at least 100 phagocytic cell as according to the following formula;

$$\% \text{ of phagocytic activity} = \left[\frac{\text{No. of phagocyte cell have in gested bacteria}}{\text{Total of phagocyte}} \right] \times 100$$

$$\text{Index of phagocyte activity} = \frac{\text{No. of ingested bacteria by phagocyte cell 100 cells}}{100}$$

Fecal sample was collected on day 0, 14, 28, 42, 56, 70 and 84 in the morning. Total stools of each goat kid were removed from the floor of the pen and kept at 4°C for bacterial enumeration. Microbiological analyses were as follows. Enumeration of mesophilic lactic acid bacteria (ISO 15214, 1998). The plating was performed into MRS medium (de Man, Rogosa and Sharpe. Difco®) from the prepared (10-1 to 10-3) by a duplicated pour plate method. The colonies were counted after

incubation at 37°C for 48 hours under anaerobic conditions by double-layer MRS medium (ISO 15214, 1998). The dishes containing 15 to 30 colonies were examined. The calculation of mesophilic lactic acid bacteria were done as follows. General case. Calculations of APC was done according to the following formula

$$N = \frac{\Sigma C}{[(n1 \times 1) + (n2 \times 0.1)] \times (d)}$$

Where

N = Number of colonies per gram of product

∑c = Sum of all colonies on all plate counted

n1 = Number of plates in first dilution counted

n2 = Number of plates in second dilution counted

d = Dilution from which the first count were obtained

Estimation of low numbers. If the two dishes contained less than 15 colonies, the formula was simplified and only the arithmetical mean was used for calculation;

$$N = \frac{y}{d}$$

y = arithmetical mean of the colonies counted on two dished

d = the dilution factor of the initial suspension

If the two dished did not contain any colonies, the results are to be expressed as follows

- Less than 1/d aerobic bacteria per gram where d is the dilution factor of the initial suspension

Enumeration of *Escherichia coli* (ISO-4831, 1991). The total numbers of *Escherichia coli* was determined by the three tubes most probable number (MPN). Lauryl Sulphate Tryptose broth (LTB) was used as selective enrichment medium. Brilliant Green Lactose Bile Broth (BGLB) and EC-medium were used as confirmation medium. The number of tubes that showed gas formation in the BGLB and EC-confirmation-broth was counted. The probable number of *Escherichia coli* were calculated according to the MPN tables (de Man, J.C. MPN tables. ISO 4831.1991).

4.4.2.3 Faecal sampling

Faecal score : Faecal samples was collected from each kid by retrieval from the rectum on the day 0, 14, 28, 42, 56, 70 and 84 at 07.00 h according to Kara et al. (2012). Faecal samples was scored with regard to consistency by the same researcher on all collection days according to the following system : 1 = watery, diarrhoea; 2 = soft, unformed; 3 = soft, formed; 4 = hard, formed and 5 = hard, dry pellets. Faecal pH was measured immediately following the collections. An electronic pH meter (PT-10, Sartorius AG, Goettingen, Germany) fitted with a glass electrode was used to determine faecal pH. Each faecal sample was placed in a 50 ml beaker and diluted 10-fold with distilled water as described by Verlinden et al. (2006). The mixture of faecal sample and distilled water was homogenized and pH was measured.

Fecal samples was collected and weighed during the last 7 days of each period. The fecal samples were collected about 5% of total fresh weight and divided into two parts, the first part being analyzed for DM, the second part kept for chemical analysis at the end of each period.

Concentrates and roughages was sampled daily during the collection period and were composted by period prior to analysis. During the last 7 days

of each period, feed samples was collected every day and divided into two parts, the first part being analyzed for DM, while the second part kept and pooled at the end of each period for chemical analysis. Samples were dried at 60°C and ground (1 mm screen using Cyclotech Mill, Tecator, Sweden) and then analyzed for DM, OM, ash and CP content (AOAC, 1990), NDF, ADF (Goering and Van Soest, 1970).

4.4.2.4 Urine sampling

Total urine was collected on the same day with feces by using plastic container within drop of concentrate sulfuric acid (10%) to avoid nitrogen losing. The urinary samples were collected about 10% of volume and kept in refrigerator and pooled at the end of period to analyze for NH_3-N by Beecher and Whitton, (1965) for determining nitrogen balance.

4.4.2.5 Metabolism trial

Metabolism trial of 7 days collection was conducted for nutrient utilization in goats. The metabolic cages were specially designed with a facility for separate collection of feces and urine. The animals were kept in metabolic cages for 3 days, prior to actual collection of 7 days to acclimatize the animals to the new surroundings. The appropriate aliquots of feed offered, residue left, feces were preserved animal wise for the day for chemical analysis. Body weight of the animals was recorded before and after the metabolism trials. Measurement data of feed offer and residue were obtained.

4.4.3 Statistical analysis

All data was statistically analyzed according to a Randomized Complete Block Design (RCBD). Significant differences between treatments were determined

using Duncan's News Multiple Range Test (DMRT) Orthogonal contrast analysis by SAS (1996).

4.4.4 Experimental location

The experiment was conducted at Suranaree University of Technology's goat farm, the Chemical analysis was performed at the Center for Scientific and Technological Equipment (CSTE), Buildings 1 and 10, Suranaree University of Technology and microbiology laboratoty of K.M.P. BIOTECH CO., LTD.

4.4.5 Experimental period

The experiment was from November, 2015 to August, 2016.

4.5 Results and discussions

4.5.1 Feed chemical composition

All animals received a diet composing of whole plant silage plus concentrate. The diet was adequate to meet the requirements of crude protein, growth net energy, and dry mater intakes of the goats under the condition of maintenance plus lower activity and 50 g/d weight gain (Nutrient analyses of the feeds were performed according to the Association of Official Analytical Chemists (AOAC, 1995). Contained the main ingredients; ground corn grain, fish meal, penut meal, repseed meal, coconut meal, wheat bran, rice bram, leucaena, cassava ship, corn gluten meal, sunflower meal, barley, molasses, vegetable oil, mineral and vitamin mix, limestone, salt.) (CP-NUMBER 991-18, as to the concentrate, it contained CP 18.0%, Fat 3.0%, Fiber 9.0% and moisture 13%). The analysis of milk composition it contained of fat 3.63%, protein 3.42%, lactose 4.74%, Ash 0.71% and moisture 87.5%.

Table 4.1 Nutrient compositions of starter concentrate and pangola hay on a dry matter basis[1].

Item (%)	Concentrate[2]	Pangola hay	Jerusalem artichoke
Dry matter	90.05	86.32	90.25
		%.....	
Crude protein	20.81	6.98	7.52
Organic matter	92.98	90.77	98.98
NDF	23.14	62.76	13.84
ADF	11.51	42.15	8.39
Ether extract	4.35	2.04	0.97
Acid insoluble ash	7.02	9.23	1.02
Inulin (g/100g)[3]			61.68

[1]Nutrient analyses of the feeds were performed according to the Association of Official Analytical Chemists (AOAC, 1995). [2]Contained the main ingredients; ground corn grain, fish meal, peanut meal, rape seed meal, coconut meal, wheat bran, rice bran, leucaena, cassava ship, corn gluten meal, sunflower meal, barley, molasses, vegetable oil, mineral and vitamin mix, limestone, salt. [3]Inulin (g/100g dry weight). NDE = Neutral detergent fiber, ADF = Acid detergent fiber.

4.5.2 Productive performance, fecal score and bacteria population

Final body weight were recorded as; 17.91 kg (T1), 24.89 kg (T2), 20.15 kg (T3), 21.58 kg (T4) and 21.68 kg (T5). Results showed that the T2, T4 and T5 treatment group, supplementation of inulin, significantly improved body weight ($p<0.05$) when compared to control dirt (T1) and T3. Feed intake at 75 day records

show; 473.53 (T1), 471.95 (T2), 458.45 (T3), 457.97 (T4) and 456.92 (T5) g/day. Treatment groups T1 and T2 showed a significantly higher feed in take ($p<0.05$) when compared to treatment groups T3, T4 and T5. Average daily gains at 90 day (135.83, 321.67, 256.67, 284.17 and 133.34 g/day in T1, T2, T3, T4 and T5, respectively) results showed the T2, T3 and T4 tretment group supplementation of inulin were significantly increase ($p<0.05$). And the study found that level of supplementation and sorce of inulin affects the increase average daily gains (ADG), but not sex effect detected. It is postulated that increase in body weight might be ascribed due to incremented fermentation at the small intestine followed by incremented floe of microbial nitrogen at astronomically immense intestine, stable microflora composition at rumen, minute and astronomically immense intestine of calves (Verdonk et al., 1998).

The results showed that fecal score at 56 day were recorded as; 2.75 (T1), 4.25 (T2), 4.00 (T3), 4.50 (T4) and 3.00 (T5), results showed that the T2, T3 and T4 treatment group, supplementation of inulin, was significantly increase ($p<0.05$). Lactic acid bacteria at 56 day; 4.60 (T1), 6.20 (T2), 6.00 (T3), 5.55 (T4) and 5.98 (T5) $\log_{10}$/g, was significantly increased ($p<0.05$), all the group has supplementation of inulin, meanwhile no increase in *Escherichia coli* among dietary treatments. The capability of inulin supplementation expands sustenance for helpful microorganisms in the body. This builds the number and action of these organisms in the gut. To control the measure of microscopic organisms as a punishment, adhering to demoralize rivalry or catch surface and enhances intestinal microbial equalization inside the exhibit. The driver was removed from enteric pathogens (Ross, 1999; Baurhoo et al., 2007). Moreover, there were no distinctive differences in fecal score, fecal pH and fecal bacterial populaces (*Escherichia coli*, lactic corrosive microbes and aggregate microorganisms).

Kara et al. (2012) examined impacts of inulin supplementation on fecal qualities and soundness of neonatal, milk-fed Saanen kids fecal scores were comparative between gatherings in the present study. Hill et al. (2008), examined impacts of encouraging FOS and MOS in dairy calves and found an unreasonable measure of maturation of fructans by colonic microorganisms can prompt expanded gas development, stomach issues and free defecation. Be that as it may, Flickinger et al., (2003) noticed degradation of inulin is faster at pH 6.0 than at unbiased pH by rumen inoculums from sheep kept up on sole search diets. The eating routine of calves supplemented with oligofructose brought about diminished populace of fecal *Escherichia coli* and all out anaerobic microflora while Bifidobacteria populace showed expanding patterns (Bunce et al., 1995). This may be credited by gainful impacts brought out through the utilization of prebiotics took after by their aging at hindgut of calves. Joining of oligofructose in the milk replacer of calves brought about enhanced body weight picks up, food transformation productivity with diminishment in the occurrence of the runs and firmer dung (Mul, 1997). In this manner influencing the retention of sustenance. Subsequently, creature sustenance, can be utilized as a part of the developing procedure the development has expanded. (Awad et al., 2008) Meanwhile, the in clude of microscopic organisms the index (caecum) found to have lower of levels Ammonia (0.673 mg/l) in 25th and disease of *Escherichia coli* (1.3×104) in the digestive system. In the gathering has supplementing a level of 0.05 percent. There is a pattern of *Escherichia coli* microscopic organisms are declining clearly. The lessening of microorganisms was to be faulted for example, Clostridium and *Escherichia coli* makes measure of smelling salts in the intestinal tract and in the blood diminished have the impact of hindering cancer-causing agents. Fat amalgamation in the liver subsequently,

lipid and cholesterol in the blood diminished. (Schijver, 2001; Kaur and Gupta, 2002) Swanson and Fahey (2002) Said key part of Bifidobacteria and Lactobacilli have chemicals disintegrate proteins bunch azoreductase nitroductas nitrate reductase and β-glucuronides low the protein causes these poisons. Impact of inulin in jerk feast upon hematological characteristics of goat kids.

4.5.3 Plasma cholesterol, hematological traits and phagocytic activity

The results showed that plasma cholesterol at 84 day were recroeded as; 140.25 (T1), 155.75 (T2), 142.75 (T3), 159.00 (T4) and 151.00 (T5) mg/dl and red blood cell (RBC) at 84 day; 7.57 (T1), 8.99 (T2), 8.67 (T3), 8.92 (T4) and 8.81 (T5) 106/ul. Results showed that the treatment group supplementation of inulin significantly increased ($p<0.05$) when compared to control dirt (T1), specifically the suppiementtation of inulin extract from Jerusalem artichoke at 2% (T2) and commercial inulin at 2% (T4). While, the value of white blood cell (WBC), lymphocyte, neutrophils and monocyte were not different ($p>0.05$), among dietary treatments. Mean estimations of each hematological quality were inside reference ranges (Jackson and Cockcroft, 2002) in both CG and EG. Be that as it may, grown-up pooches supplemented with MOS had a higher lymphocyte fixation than control mutts in their study. Davis et al. (2004) watched the expansion in blood lymphocyte fixation and the decline in blood neutrophil focus when pigs were supplemented with 0.3% MOS. The expansion in blood lymphocytes might be valuable in providing protection against pathogens, though the decline in blood neutrophil fixation might be a negative result of sustaining prebiotics as neutrophils assume a key part in the primary line of safeguard against irresistible living beings (Davis et al., 2004). Masanetz et al. (2011) reported no adjustment in the aggregate WBC tally, blood neutrophil, lymphocyte and

monocyte centralizations of calves encouraged the eating routine containing 2% inulin. Nonetheless, hemoglobin level in blood of all calves was comparative toward the start of analysis though hemoglobin level in 56 day in calves that got inulin in sum 3 g/day/head was higher than in calves from others bunches. Hematocrit level both at starting and toward the end of analysis in calves from all gatherings was comparable (Babara, 2011).

For the test period, the results of this experiment showed that the percentages of phagocyte activity (%PA) and index of phagocyte activity (IPA) the number of engulfed *Escherichia coli* (strain ATCC 25922). It was found that %PA at 42 and 70 day was significantly increased ($p<0.05$), showed that the T2, T3 and T4 treatment group, supplementation of inulin (Table 4.4). And the results showed that IPA at 70 and 84 day was significantly increased ($p<0.05$) specifically the suppiementtation of inulin extract from Jerusalem artichoke at 2% (T2). The consequences of this trial demonstrated that the rates of phagocyte movement (%PA) action of the goat kids supplemented of inulin from Jerusalem artichoke and business inulin (Table 4.6). These results showed that amid the trial, the goat kid supplemented with 2% of DM inulin from Jerusalem artichoke and 4% of DM commercial inulin had the best %PA. These rates of the trial were likewise more noteworthy than the rates at the test in the present review, the %PA increment as the Lactic acid bacteria number increment. It is conceivable that there is certain relationship between the quantity of Lactic acid bacteria and %PA. The phagocytosis of microorganisms represents to one of the nonspecific protection instruments of essential significance for the host. The monocyte/macrophage cell lines, usually alluded to as expert phagocytes, can kill, overwhelm and pulverize particles, including irresistible operators, in this manner

displaying a high phagocytic potential (Aderem and Underhill, 1999). In this regard, these cells have been as often as possible assessed for phagocytic and lytic limit against pathogenic microorganisms. Because innate immune replication constitutes the first line of bulwark against invading pathogens. Phagocytosis mechanism is a component of innate immune replication and is, consequently, essential for organism auspice. Phagocytes activity involves kinetics processes in replication to chemotaxis stimulus, adhesion, eradication and abstraction of digested particles. Failures in the phagocytic activity leads to immune deficiencies than can include bacterial and fungal chronic and recurring infections (Lehmann et al., 2000 and Dinauer, 2005). Maitreepawit (2008) reported for the trial the rates of phagocyte movement (%PA) and list of phagocytic (IPA) action of the puppy supplemented with 2% FOS were the best. The consequences of Verlinden et al. (2006) and Masanetz et al. (2011) were in concurrence with those of our study. Contemplates where a safe test is exhibited might be directed to figure out if changes in the centralizations of lymphocyte and neutrophil from blood insusceptible attributes are auxiliary or harmful. Distinctive hematological results on the impacts of inulin or other prebiotic mixes might be acquired for kids confronting an insusceptible test. However, phagocytic activity (PA) of polymorph nuclear and mononuclear blood leukocytes from sheep and goats was quantified utilizing two variants of inert particles ingestion. The percentage of phagocytizing cells reached up to 67.83% in granulocytes and 3.74% in monocytes as resolute by 2-hydroxyethylmethacrylate particles (MSHP) in sheep and goats. The PA determined by denotes of CdCO. Microcrystals saturated with human serum albumin (Cd-HSA) was 30-50% doter then the MSHP values, categorically in sheep (Benda and Hospes, 1991).

Table 4.2 The effects of inulin supplementation on productive performance of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Initial weight (kg)	3.68	4.10	3.57	3.74	4.41	0.10	0.078	ns	ns	ns
Final weight (kg)	17.91^{a}	24.89^{b}	20.15^{a}	21.58^{ab}	21.68^{ab}	0.59	0.049	*	ns	ns
Increase weight (kg)	14.24^{a}	20.79^{b}	16.41^{a}	17.83^{ab}	17.26^{ab}	0.56	0.041	*	ns	ns
Feed intake; 30 day (g)	696.67	696.67	696.67	696.67	696.67	0.00	1.000	ns	ns	ns
Feed intake; 75 day (g)	473.53^{a}	471.95^{a}	458.45^{b}	457.97^{b}	456.92^{b}	9.81	0.011	*	*	*
Feed intake; 90 day (g)	599.64^{a}	608.84^{a}	579.72^{b}	579.20^{b}	584.20^{ab}	14.20	0.019	*	*	*
ADG 30 day(g/day)	176.25	182.09	152.09	162.08	228.33	12.15	0.396	ns	ns	ns
ADG 75 day(g/day)	153.61	226.67	177.78	193.34	186.84	9.29	0.531	ns	ns	ns
ADG 90 day(g/day)	135.83^{a}	321.67^{b}	256.67^{b}	284.17^{b}	133.4^{a}	15.56	0.012	*	*	*

^{a,b,c} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%), ADG = average daily gain, and SEM = standard error of mean.

Table 4.3 The effects of inulin supplementation on fecal score and fecal pH of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Fecal score[1]										
0 day	2.00	2.00	2.00	2.50	2.00	0.17	0.845	ns	ns	ns
14 day	2.50	3.00	2.75	3.25	2.75	0.11	0.209	ns	ns	ns
28 day	3.75	4.25	3.75	4.25	3.75	0.27	0.763	ns	ns	ns
42 day	3.50	4.75	3.50	4.75	2.75	0.92	0.178	ns	ns	ns
56 day	2.75[a]	4.25[b]	4.00[b]	4.50[b]	3.00[a]	0.49	0.047	*	ns	ns
70 day	3.25	4.75	4.00	4.75	4.25	0.54	0.085	ns	ns	ns
84 day	4.75	5.00	5.00	5.00	5.00	0.05	0.486	ns	ns	ns
Fecal pH	7.34	6.96	7.12	6.99	7.06	0.11	0.542	ns	ns	ns

[a,b] Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%). [1]Fecal scoring system; 1 = watery, diarrhoea; 2 = soft, unformed; 3 = soft, formed; 4 = hard, formed; and 5 = hard, dry pellets. and SEM = Standard error of mean.

Table 4.4 The effects of inulin supplementation on fecal bacterial populations of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Fecal bacteria population[2]										
***Escherichia coli* (MPN)**										
0 day	4.40	4.35	4.38	4.00	3.68	1.59	0.930	ns	ns	ns
14 day	4.93	4.43	5.73	4.95	4.90	0.69	0.060	ns	ns	ns
28 day	5.65	4.45	5.40	4.88	5.03	0.49	0.284	ns	ns	ns
42 day	5.73	4.83	5.83	4.70	5.88	0.57	0.061	ns	ns	ns
56 day	4.80	4.98	5.23	4.50	5.48	0.76	0.726	ns	ns	ns
70 day	5.28	4.79	4.88	4.43	5.15	0.53	0.415	ns	ns	ns
84 day	5.73	4.80	4.95	4.53	5.05	0.46	0.117	ns	ns	ns

Table 4.4 The effects of inulin supplementation on fecal bacterial populations of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Lactic acid bacteria (log_{10}/g)										
0 day	6.23	4.55	6.10	4.23	4.23	1.57	0.276	ns	ns	ns
14 day	4.23	5.50	5.93	6.93	6.45	0.75	0.099	ns	ns	ns
28 day	4.75	5.75	5.65	5.68	5.88	0.65	0.210	ns	ns	ns
42 day	4.63	5.80	5.63	5.60	5.93	0.50	0.325	ns	ns	ns
56 day	4.60^{a}	6.20^{b}	6.00^{ab}	5.55^{ab}	5.98^{ab}	0.71	0.018	*	ns	ns
70 day	4.63	5.53	5.48	5.70	5.53	0.46	0.643	ns	ns	ns
84 day	4.65	5.40	5.20	5.75	5.28	0.48	0.441	ns	ns	ns
Total bacteria (log_{10}/g)	6.42	6.36	6.17	5.98	6.11	0.43	0.823	ns	ns	ns

[a,b] Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%). [2]Bacterial populations in sterile feces sampled from a subset (n =10) of healthy kids in each group on day 14, 28, 42, 56, 70 and 84, MPN = most probable number of coliform organisms (*Escherichia coli*) obtain three most probable number table/100 ml, log_{10} = a logarithm to the base 10 and SEM = Standard error of mean.

Table 4.5 The effects of inulin supplementation on plasma cholesterol, hematological traits of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Plasma cholesterol (mg/dl)										
0 day	140.50	139.50	135.75	144.75	145.75	6.36	0.576	ns	ns	ns
28 day	152.50	157.75	161.50	157.00	156.00	12.64	0.649	ns	ns	ns
56 day	149.25	171.50	159.25	154.00	168.00	7.43	0.589	ns	ns	ns
84 day	140.25^{a}	155.75^{b}	142.75^{a}	159.00^{b}	151.00^{b}	8.76	0.032	*	ns	*
White blood cell (WBC), 10^{4}/µl										
0 day	1.67	1.87	2.15	1.81	1.82	0.69	0.891	ns	ns	ns
28 day	1.76	1.83	2.51	1.72	1.92	0.59	0.472	ns	ns	ns
56 day	2.52	1.86	2.94	1.73	1.73	0.74	0.378	ns	ns	ns
84 day	3.37	2.04	3.19	1.82	1.92	0.24	0.053	ns	ns	ns

Table 4.5 The effects of inulin supplementation on plasma cholesterol, hematological traits of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Lymphocytes, %/µl										
0 day	52.75	52.00	52.25	53.25	51.00	4.93	0.985	ns	ns	ns
28 day	57.50	53.25	49.25	54.25	55.25	5.91	0.507	ns	ns	ns
56 day	47.75	54.25	58.00	52.50	52.75	6.51	0.721	ns	ns	ns
84 day	53.25	47.00	52.00	48.75	53.00	3.74	0.526	ns	ns	ns
Neutrophils, %/µl										
0 day	33.00	34.50	33.00	34.25	32.50	0.37	0.657	ns	ns	ns
28 day	49.25	41.00	45.25	42.75	37.25	0.48	0.067	ns	ns	ns
56 day	47.50	42.25	45.25	38.50	47.00	0.50	0.064	ns	ns	ns
84 day	48.50	40.75	44.00	43.25	45.75	0.28	0.051	ns	ns	ns
Monocytes, %/µl										
0 day	1.25	1.50	1.25	1.75	1.25	0.49	0.087	ns	ns	ns
28 day	1.50	1.75	1.50	1.50	1.75	0.54	0.463	ns	ns	ns
56 day	3.50	4.25	4.75	2.25	2.75	1.33	0.117	ns	ns	ns
84 day	1.75	2.25	3.50	2.25	2.75	1.16	0.094	ns	ns	ns

Table 4.5 The effects of inulin supplementation on plasma cholesterol, hematological traits of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Eosinophils, %/µl										
0 day	1.36	1.73	1.45	1.51	1.148	0.07	0.217	ns	ns	ns
28 day	3.24	3.58	3.55	3.14	3.34	0.09	0.732	ns	ns	ns
56 day	4.73	4.67	4.49	4.71	4.63	0.14	0.248	ns	ns	ns
84 day	4.66	4.53	4.35	4.52	4.51	0.49	0. 637	ns	ns	ns
Red blood cell (RBC), 10^6/µl										
0 day	7.62	8.61	9.05	7.57	7.81	0.76	0.278	ns	ns	ns
28 day	8.24	8.85	7.32	7.69	7.62	0.98	0.724	ns	ns	ns
56 day	8.09	7.89	7.50	8.15	8.26	0.81	0.795	ns	ns	ns
84 day	7.57^a	8.99^b	8.67^b	8.92^b	8.81^b	0.44	0.018	*	ns	ns

Table 4.5 The effects of inulin supplementation on plasma cholesterol, hematological traits of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Hemoglobin, g/dl										
0 day	7.75	7.88	7.55	7.10	7.16	0.49	0.093	ns	ns	ns
28 day	8.10	8.53	7.83	7.93	7.60	0.69	0.212	ns	ns	ns
56 day	8.03	8.18	7.93	8.35	8.70	0.25	0.748	ns	ns	ns
84 day	8.80	9.33	8.63	9.20	9.45	0.25	0.551	ns	ns	ns
Hematocrit, %/µl										
0 day	20.18	21.15	20.45	19.53	19.75	0.35	0.511	ns	ns	ns
28 day	22.33	22.55	20.15	20.98	21.30	0.63	0.099	ns	ns	ns
56 day	22.23	22.58	21.05	22.18	22.68	0.67	0.212	ns	ns	ns
84 day	23.08	24.78	24.75	24.13	24.58	0.24	0.087	ns	ns	ns

[a,b] Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant ,control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) and SEM = standard error of mean.

Table 4.6 The effects of inulin supplementation on percentages of phagocyte activity (%PA) and index of phagocyte activity (IPA) of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Percentages of phagocyte activity (%PA)										
0 day	28.99	29.10	29.30	29.50	29.20	0.08	0.220	ns	ns	ns
14 day	29.25	29.84	30.23	30.13	30.31	0.16	0.514	ns	ns	ns
28 day	30.00	31.02	30.96	30.83	30.86	0.18	0.084	ns	ns	ns
42 day	30.39^{a}	32.20^{b}	31.57^{ab}	32.23^{b}	31.63^{ab}	0.17	0.049	*	ns	ns
56 day	29.87	32.35	32.64	33.29	32.42	0.24	0.083	ns	ns	ns
70 day	29.23^{a}	30.85^{b}	30.08^{ab}	30.93^{b}	29.61^{a}	0.14	0.049	*	ns	ns
84 day	29.55	32.86	31.70	32.98	32.71	0.29	0.145	ns	ns	ns

Table 4.6 The effects of inulin supplementation on percentages of phagocyte activity (%PA) and index of phagocyte activity (IPA) of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Index of phagocyte activity (IPA)										
0 day	4.11	4.21	3.92	4.12	4.20	0.06	0.784	ns	ns	ns
14 day	4.32	4.65	4.14	4.40	4.60	0.07	0.336	ns	ns	ns
28 day	3.94	4.37	4.18	4.30	4.46	0.08	0.442	ns	ns	ns
42 day	4.27	4.36	4.16	4.54	4.32	0.04	0.671	ns	ns	ns
56 day	3.85	4.43	4.11	4.30	4.26	0.06	0.266	ns	ns	ns
70 day	3.80^{a}	4.37^{b}	4.30^{ab}	4.18^{ab}	4.23^{ab}	0.07	0.041	*	ns	ns
84 day	3.88^{a}	4.52^{b}	4.02^{a}	4.23^{ab}	4.03^{a}	0.07	0.039	*	ns	*

[a,b,c] Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) and SEM = standard error of mean.

4.5.4 Dry matter intake, nutrient digestibility, nitrogen utilization, ruminal ammonia, blood urea nitrogen and volatile fatty acid proportion

The results showed that nutrient intake (organic metter, crude protein, neutral detergent fiber and acid detergent fiber) was significantly increased ($p<0.05$), specifically the control diet (T1) and inulin extracted from Jerusalem artichoke at 2% of DM (T2) results showed in Table 4.7. While, ether extract were recorded as; 7.15 (T1), 6.21 (T2), 7.04 (T3), 6.20 (T4) and 7.05 (T5) g/day, results showed that the T2 and T4 tretment group supplementation of inulin was highly significantly decrease ($p<0.01$). Percentages of appearance digestibility (organic matter, ether extract, neutral detergent fiber and acid detergent fiber) was significantly increased ($p<0.05$), specifically the inulin extracted from Jerusalem artichoke at 2% of DM (T2) and commercial inulin at 2% of DM (T4). While, total nitrogen intake were recorded as; 8.81 (T1), 8.94 (T2), 8.58 (T3), 8.55 (T4) and 8.59 (T5) gDM/day, results showed that the control diet (T1) and inulin extracted from Jerusalem artichoke at 2% of DM (T2) was significantly decrease ($p<0.05$). However, it was found that the level of supplementation affects on percentages of appearance digestibility. Meanwhile, no increase in nitrogen utilization, ruminal pH, ruminal ammonia nitrogen (NH_3-N) and blood urea nitrogen (BUN) among dietary treatments. Results showed that the level of supplementation affects on urine nitrogen. The study results of nutrient digestibility there was an increase of dry matter, organic matter, and neutral detergent fiber in the supplemented of inulin extracted from Jerusalem artichoke 2% of DM, at the same time also found that nitrogen utilization there was increase and reduction of ruminal ammonia nitroges. This is possible in which inulin could be readily and completely digested and metabolised in cow and sheep rumen fluids Biggs and Hancock (1998),

which mean that inulin also had similar extent of ruminal digestion and cause improves digestion and nutrient uptake. The rumen ammonia nitrogen concentration was slightly lower in prebiotics supplemented Holstein cows and steers, which might be due to the utilization of ammonia for microbial protein synthesis in the rumen (Mwenya et al., 2005; Santoso et al., 2003). Consistent with Samanta et al. (2013) reported the effect of prebiotic consumption in ruminant cause rumen ammonia nitrogen concentration was slightly lower. Due to the dry matter intake, nutrient digestibility is as such not affected by prebiotic supplementation but showed higher nitrogen retention owing to increased microbial protein synthesis in rumen Santoso et al. (2003). Which this shows the efficiency in generating better living this is due to the efficient digestion and nutrient utilization, may be due to the inulin effect on the increase of gastric microbes this results in improved digestion performance. However, Russell et al. (1998) reported fructo-oligosaccharide group supplementation on ruminant found protein digestibility trend to increase up to 89%. In addition, the usage inulin from Jerusalem artichoke supplementation in the diet with high quality roughage (peangola hay) on ruminant in *in vitro* found that kernel group could improve digestibility efficiency trend to higher than others groups and no affected to microbes population in the rumen, it was important to fiber fermentation. It may be Jerusalem artichoke consist high carbohydrate (Raksasiri et al., 2014). While, few data are available on the effects of inulin on ruminal NDF digestibility *in vivo* and *in vitro*, but compared the effects of inulin on forage NDF digestion kinetics using *in vitro* digestion technique and observed no difference among treatments and results suggest that inulin differ in ruminal volatile fatty acid fermentation but have similar effects on ruminal digestion and microbial synthesis *in vitro* (Rosendo et al., 2003; Zhao et al., 2014).

Total volatile fatty acid 3 h post feeding were recorded as; 91.79 (T1), 95.05 (T2), 92.79 (T3), 94.97 (T4) and 94.10 (T5) mM/L, and 6 h post feeding were recorded as; 89.73 (T1) 93.09 (T2), 91.98 (T3), 92.01 (T4) and 91.77 (T5) mM/L, Results showed that the treatment group supplementation of inulin significantly increased ($p<0.05$) when compared to control dirt (T1). Volatile fatty acid proportion (acitic acid; C_2) 6 h post feeding were recorded as; 61.32 (T1), 58.79 (T2), 59.81 (T3), 58.98 (T4) and 61.45 (T5) %mol, results showed that the treatment group supplementation of inulin highly significantly decreased ($p<0.01$) when compared to control dirt (T1), specifically the suppiementtation of inulin extract from Jerusalem artichoke at 2% (T2) and commercial inulin at 2% (T4). Propionic acid (C_3) at 3 h post feeding; 24.85 (T1), 28.24 (T2), 25.57 (T3), 27.66 (T4) and 26.16 (T5) %mol, results showed that the treatment group supplementation of inulin highly significantly increased ($p<0.01$) when compared to control dirt (T1), specifically the suppiementtation of inulin extract from Jerusalem artichoke at 2% (T2) and commercial inulin at 2% (T4). While, not significantly of butyric acid (C_4). Ratios of C_2 : C_3 at 3 h post feeding were recorded as; 2.43 (T1), 2.05 (T2), 2.33 (T3), 2.14 (T4) and 2.27 (T5), 6 h post feeding were recorded as; 2.53 (T1), 2.16 (T2), 2.38 (T3), 2.14 (T4) and 2.38 (T5), was significantly decrease ($p<0.05$) all group supplementation of inulin, specifically the suppiementtation of inulin extract from Jerusalem artichoke at 2% (T2) and commercial inulin at 2% (T4). And methane (CH_4) at 3 h post feeding; 26.24 (T1), 23.83 (T2), 25.72 (T3), 24.24 (T4) and 25.31 (T5), was highly significantly decrease ($p<0.01$) and 6 h post feeding; 26.67 (T1), 24.48 (T2), 25.99 (T3), 24.24 (T4) and 25.60 (T5), was significantly decrease ($p<0.05$) results showed that the suppiementtation of inulin extract from Jerusalem artichoke at 2% (T2) and commercial inulin at 2% (T4).

However, the study found that the level of supplementation inulin affect on volatile fatty acid proportion. And the study was to investigate the effects of inulin supplementation in creep feed effects on productive performance of goat kids not different from experiment (I) was to investigate the effects of inulin in milk on productive performance of goat kids. While, some in vitro studies ascertained that inulin increased the VFA productions at a higher extent than pectin and arabinoxylan (Marounek et al., 1999). Umucalilar et al., (2010) reported the total VFA concentration quadratically decreased with increasing forage proportion and were associated with the increase of acetate proportion and the decreases of butyrate, because of its greater solubility and increased total VFA concentration in the rumen in response to inulin addition are in agreement with literature data focusing on colon fermentation (Rosendo et al., 2003; Dijkerman et al., 1997).

Table 4.7 The effects of inulin supplementation on nutrient digestibility and nitrogen utilization of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Nutrient intake, g/day										
Ogranic matter	392.82^{ab}	400.34^{a}	383.62^{b}	382.46^{b}	383.72^{b}	1.31	0.026	*	*	*
Crude protein	55.07^{a}	55.88^{a}	53.63^{b}	53.41^{b}	53.68^{b}	0.15	0.017	*	*	*
Ether extract	7.15^{a}	6.21^{b}	7.04^{a}	6.20^{b}	7.05^{a}	0.04	0.001	**	ns	**
Neutral detergent fiber	196.71^{a}	201.23^{a}	192.55^{b}	192.14^{b}	192.50^{b}	0.77	0.037	*	*	*
Acid detergent fiber	124.77^{ab}	127.74^{a}	122.19^{b}	121.96^{b}	122.15^{b}	0.50	0.040	*	*	*
Appearance digestibility, %										
Ogranic matter	68.41^{a}	76.04^{b}	68.02^{a}	73.95^{b}	68.24^{a}	0.38	0.002	**	ns	**
Crude protein	76.87	79.23	77.93	78.38	77.51	0.68	0.793	ns	ns	ns
Ether extract	75.54^{a}	80.61^{b}	77.63^{ab}	80.42^{b}	80.42^{b}	0.44	0.004	**	*	**
Neutral detergent fiber	74.08^{a}	79.16^{b}	73.14^{a}	77.61^{b}	72.82^{a}	0.29	0.003	**	*	**
Acid detergent fiber	63.03^{a}	69.43^{c}	59.93^{b}	66.93^{c}	59.73^{a}	0.44	0.001	**	*	**

Table 4.7 The effects of inulin supplementation on nutrient digestibility and nitrogen utilization of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Nitrogen utilization (g/day)										
Nitrogen intake	8.81[a]	8.94[a]	8.58[b]	8.55[b]	8.59[b]	0.02	0.016	*	*	*
Fecal nitrogen	2.04	1.85	1.95	1.85	1.93	0.06	0.826	ns	ns	ns
Urinal nitrogen	2.86	3.16	2.92	2.95	2.85	0.03	0.109	ns	ns	ns
N absorption (g)	6.78	7.09	6.69	6.70	6.66	0.06	0.082	ns	ns	ns
N retention (g)	3.92	3.93	3.77	3.76	3.82	0.07	0.319	ns	ns	ns
N absorption (%)	76.91	79.27	77.97	78.41	77.55	0.68	0.793	ns	ns	ns
N retention (%)	44.42	43.97	43.93	43.99	44.40	0.80	0.986	ns	ns	ns

[a,b,c] Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) and SEM = standard error of mean.

Table 4.8 The effects of inulin supplementation on ruminal pH, ruminal ammonia nitrogen and blood urea nitrogen of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Ruminal pH										
0 h post feeding	7.15	7.02	7.19	7.04	7.15	0.04	0.347	ns	ns	ns
3 h post feeding	7.10	6.96	7.11	6.90	7.03	0.05	0.118	ns	ns	ns
6 h post feeding	7.11	6.92	7.01	6.86	6.98	0.05	0.743	ns	ns	ns
Ruminal NH_3-N (mg/dl)										
0 h post feeding	12.82	13.03	13.03	12.82	13.17	0.17	0.285	ns	ns	ns
3 h post feeding	16.25	15.55	15.97	15.96	13.83	0.06	0.067	ns	ns	ns
6 h post feeding	15.62	13.73	14.78	14.57	14.85	0.17	0.349	ns	ns	ns
Blood urea nitrogen (BUN) (mg/dl)										
0 h post feeding	13.25	15.25	13.25	14.05	13.25	0.42	0.527	ns	ns	ns
3 h post feeding	14.07	16.66	16.50	15.25	15.75	0.57	0.128	ns	ns	ns
6 h post feeding	14.50	15.25	16.25	16.00	14.50	0.62	0.228	ns	ns	ns

ns = non-significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) NH_3-N = ammonia nitrogen, BUN = blood urea nitrogen and SEM = Standard error of mean.

Table 4.9 The effects of inulin supplementation on volatile fatty acid proportion of goat kids.

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Total volatile fatty acid (mM/L)										
0 h post feeding	91.70	93.81	92.79	94.21	93.20	0.27	0.051	ns	ns	ns
3 h post feeding	91.79^{a}	95.05^{b}	93.99^{b}	94.97^{b}	94.10^{b}	0.22	0.035	*	ns	ns
6 h post feeding	89.83^{a}	93.09^{b}	91.98^{b}	92.01^{b}	91.77^{b}	0.22	0.026	*	ns	ns
Volatile fatty acid proportion (%mol)										
Acitic acid (C_2)										
0 h post feeding	61.04	59.14	58.57	59.67	60.22	0.28	0.383	ns	ns	ns
3 h post feeding	60.20	57.78	59.49	59.13	59.24	0.30	0.454	ns	ns	ns
6 h post feeding	61.32^{ab}	58.79c	59.81^{bc}	58.98^{c}	51.45^{a}	0.22	0.002	**	*	**
Propionic acid (C_3)										
0 h post feeding	25.23	27.99	26.94	26.45	26.34	0.32	0.081	ns	ns	ns
3 h post feeding	24.85^{a}	28.24^{c}	25.57^{ab}	27.66^{c}	26.16^{b}	0.16	0.004	**	ns	**
6 h post feeding	24.29	27.35	25.19	27.72	25.89	0.26	0.061	ns	ns	ns

Table 4.9 The effects of inulin supplementation on volatile fatty acid proportion of goat kids (Continued).

Items	Inulin levels in rations (%)					SEM	P-value	Contrast		
	T1 *(Cont.)*	T2 *(Ext. 2%)*	T3 *(Ext. 3%)*	T4 *(comm. 2%)*	T5 *(Comm. 4%)*			trt	A*B	C*D
Butyric acid (C_4)										
0 h post feeding	13.73	12.87	14.49	13.88	13.43	0.22	0.458	ns	ns	ns
3 h post feeding	14.95	13.98	14.95	13.21	13.61	0.32	0.571	ns	ns	ns
6 h post feeding	14.39	13.87	15.01	13.31	12.67	0.21	0.195	ns	ns	ns
Ratios of C_2 : C_3										
0 h post feeding	2.43	2.12	2.19	2.26	2.29	0.04	0.123	ns	ns	ns
3 h post feeding	2.43^{a}	2.05^{d}	2.33^{ab}	2.14^{cd}	2.27^{bc}	0.02	0.014	*	ns	*
6 h post feeding	2.53^{a}	2.16^{b}	2.38^{a}	2.14^{b}	2.38^{a}	0.03	0.019	*	ns	*
Methene (CH_4)										
0 h post feeding	26.02	24.06	24.75	25.13	25.23	0.22	0.092	ns	ns	ns
3 h post feeding	26.24^{a}	23.83^{c}	25.72^{ab}	24.29^{c}	25.31^{b}	0.11	0.004	**	ns	**
6 h post feeding	26.67^{a}	24.48^{bc}	25.99^{a}	24.24^{c}	25.60^{ab}	0.18	0.045	*	ns	*

^{a,b,c,d} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A*B = contrast with inulin extract and commercial inulin (T2,T3 : T4,T5), C*D = contrast with lavel of supplementation inulin (2% : 4%) and SEM = standard error of mean.

4.6 Conclusions

The impact of inulin in wet blanket is beneficial to hematological attributes of goat kids, resulting in production performance and fecal score. Specifically, inulin extracted from Jerusalem artichoke, supplemented at 2% DM, has proven to enhance feed consumption, average daily gains and final body weights. These improvements are to influence microbial populations, phagocyte action, nutrient digestion and volatile fatty acid proportion. Additionally future research of prebiotic application in livestock should consider immunological aspects and livestock product quality therapeutic aspects with more emphasis on common gastrointestinal disorders.

4.7 References

Aderem, A., and Underhill, D.M. (1999). Mechanisms of phagocytosis in macrophages. **Annual Review of Immunology**. 17: 593-623.

AOAC. (1995). Official Method of Analysis 16th ed. Association of Official Analytical Chemist, Washington, DC.

Awad, W., Ghareeb, K., and Böhm, J. (2008). Intestinal structure and function of Broiler chickens on diets supplemented with a symbiotic containing *Enterococcus* faecium and oligosaccharides. **International Journal of Molecular Sciences**. 9: 2205-2216.

Babara, K. (2011). Effect of mannan-oligosaccharides, inulin and yeas nucleotides added to calf milk replacers on rumen microflora, level of serum immunoglobulin and health condition of calves. **Electronic Journal of Polish Agricultural Universities**. 14: 18.

Baurhoo, B., Letellier, A., Zhao, X., and Ruiz-Feria, C.A. (2007). Fecal populations of Lactobacilli and Bifidobacteria and *Escherichia coli* after in vivo *Escherichia coli* challenge in birds fed diets with purified lignin or mannanoligo-saccharides. **Poultry Science**. 86: 2509-251.

Benda, V., and Hoiipes, J. (1991). Phagocytic Activity of Leukocytes in Sheep and Goats. **Acta Veterinary Brno**. 60: 149-152.

Bunce, T.J., Howard, M.D., Kerley, M.S., and Allece, G.I. (1995). Feeding fructooligosaccharides to calves increased Bifidobacterium and decreased Escherichia coli. **Journal of Animal Science**. 73: 281.

Biggs, D.R., and Hancock, K.R. (1998). In vitro digestion of bacterial and plant fructans and effects on ammonia accumulation in cow and sheep rumen fluids. **Journal of General and Applied Microbiology**. 44: 167-171.

Davis, M.E., Maxwell, C.V., Erf, G.F., Brown, D.C., and Wistuba, T.J. (2004). Dietary supplementation with phosphorylated mannans improves growth response and modulates immune function of weanling pigs. **Journal of Animal Science**. 82: 1882-1891.

Dinauer, M.C. (2005). Chronic granulomatous disease and other disorders of phagocyte function. **Hematology**. (1): 89-95.

Dobre, T., Stroescu, M., Stoica, A., Draghici. E., and Antohe, N. (2008). Inulin extraction and encapsulation. **Chemical Bulletin of Politehnica University of Timisoara**. 35: 215-217.

Flickinger, E.A., Van Loo, J., and Fahey, G.C. (2003). Nutritional responses to the presence of inulin and oligofructose in the diets of domesticated animals; a review. **Critical Reviews in Food Science and Nutrition**. 43: 19-60.

Gibson, G.R., and Roberfroid, B. (1995). Dietary modulation of the human colonic microbiota; Introducing the concept of prebiotic. **Journal of Nutrition**. 125: 1401-1412.

Hill, J.C., Dunn, K.M., Lewis, M., Mullis, R., Main, C.J., and Foster, N.E. (2008). A primary care back pain screening tool; identifying patient subgroups for initial treatment. **Arthritis and Rheumatology**. 59: 632-641.

ISO-4831. (1991). Microbiology-general guidance for enumeration of presumptive *Escherichia coli*-most probable number technique. 70-83.

ISO-15214. (1998). Microbiology of food animal feeding stuffs-horizontal method for the enumeration of mesophilic lactic acid bacteria-colony-count technique at 30°C. Microbiology. 23-41.

Jackson, P.G.G., and Cockcroft, P.D. (2002). Normal physiological values. In clinical examination of farm animals. Wiley-Blackwell, Oxford, UK. 301 p.

Kara, C., Orman, A., Gencoglu, H., Kovanlıkaya, A., Meral, Y., Cetin, I., Yıbar, A., Kasap, S., Turkmen, I., and Deniz, G. (2012). Effects of inulin supplementation on selected fecal characteristics and health of neonatal Saanen kids sucking milk from their dams. **Animal**. 6: 1947-1954.

Kaur, N., and Gupta, A.K. (2002). Applications of inulin and oligofructose in health and nutrition. **International Journal of Biological Sciences**. 27: 703-714.

Lehmann, A.K., Sornes, S., and Halstensen, A. (2000). Phagocytosis: measurement by flow cytometry. **Journal of Immunological Methods**. 243: 229-242.

Maitreepawit, S. (2008). The effects of fructooligosaccharide supplementation on gut microflora, nutrient digestibility, plasma cholesterol and phagocyte activity in adult dogs. A thesis submitted in partial fulfillment of the requirements for the

degree of master of scienceprogram in animal nutrition department of animal husbandry, faculty of veterinary science, Chulalongkorn University. 53 p.

Masanetz, S., Preißinger, W., Meyer, H.H.D., and Pfaffl, M.W. (2011). Effects of the prebiotics inulin and lactulose on intestinal immunology and hematology of preruminant calves. **Animal**. 5: 1099-1106.

Mul, A.J. (1997). Application of oligofructose in animal feeds. In **Proceedings of International Symposium Non-Digestible Oligosaccharides; Healthy Food for colon?** (pp 106). The Netherlands; Wageningen.

Mwenya, B., Sar, C., Santoso, B., Gamo, Y., Kobayashi, T., Morikawa, R., Takura, K., Umetsu, K., Kogawa, S., Kimura, K., Mizukoshi, H., and Takahashi, J. (2005). Comparing the effects of beta 1,4-galactooligosaccharides, and L-cysteine to monensin on energy and nitrogen utilization in steers fed a very high concentrate diets. **Animal Feed Science and Technology**. 118: 19-30.

Raksasiri, B.V., Vorlaphim, T., Khotsakdee, J., Paengkoum, S., and Paengkoum, P. (2014). The study of nutritive values and *in vitro* gas production of Jerusalem Artichoke with pangola hay as roughage. In **Proceedings of the 16th AAAP Animal Science Congress** (pp 1807-1809).

Rosendo, O., Hall, M., Staples, C., and Bates, D., (2003). The effect of different neutral detergent soluble polysaccharides in digestive cynetics in vitro of neutral detergent forage fiber and the synthesis of microbial protein [On-line]. Available: http://revistas.luz.edu.ve/index.php/rc/article/viewFile/4560/4428.

Ross, G.C. (1999). Prebiotic, P. 141-156. In W.T. Geral (ed.). **Prebiotics a Critical Review**. Wymondham; Horizon Scientific Press.

Russell, T.J., Kerley, M.S., Allee, G.L., and Howard, M.D. (1998). Fructooligosaccharides improves nitrogen metabolism and reducesfecal excretion of metabolites in the weaned pig. **UMC Animal Sciences Department Report**. 79-83.

Santoso, B., Kume, S., Nonaka, K., Gamo, Y., Kimura, K., and Takashi, J. (2003). Influence of beta galactooligosaccharide supplementation on nitrogen utilization, rumen fermentation, and microbial nitrogen supply in dairy cows fed silage. **Asian Australasian Journal of Animal Science**. 26: 1137-1142.

Statistical Analysis System. (1996). SAS/STAT User's Guide: Statistics, Version 6.12 edition. SAS Inc., Cary, NC, USA.

Swanson, K.S., and Fahey, G.C. (2002). Prebiotics in companion animal nutrition. In T.P. Lyons and K.A. Jacques (eds.). **Biotechnology in the feed industry. Proc. Alltech's 18th Ann. Symp** (pp 461-473). Loughborough; UK, Nottingham University Press.

Tapingkae, W. (2014). Alternatives to the use of antibiotics as growth promoters for livestock animals. **Journal of Agricultural Science**. 30: 201-212.

Younes, H., Garleb, K., Behr, S., Rémésy, C., and Demigné, C. (1995). Fermentable fibers or oligosaccharides reduce urinary nitrogen excretion by increasing urea disposal in the rat cecum. **Journal of Nutrition**.125: 1010-1016.

Verdonk, J.M.A.J., Beelan, G.M., Jansman, A.J.M., and Huismam, J. (1998). Effect of soya carbohydrate fraction on the ileal digestibility and endogenous flow of nitrogen in veal calves. In A.J.M. Jansman, G.D. Hill, J. Huisman and A.F.B. Vander Poel (eds.). **Recent Advances of Research in Antinutritional Factors in Legume Seeds** (pp 341-343). The Netharlands; Wageningen.

Verlinden, A., Hesta, M., Hermans, J.M., and Janssens, G.P.J. (2006). The effects of inulin supplementation of diets with or without hydrolyzed protein sources on digestibility, fecal characteristics, hematology, and immunoglobulins in dogs. **British Journal of Nutrition**. 96: 936-944.

Zhao, X.H., Jian, M.G., Shan, Z., Chan, J.L., and Ming, R.Q. (2014). The effect of starch, inulin and degradable protein on ruminal fermentation and microbial growth in rumen simulation technique. **Italian Journal of Animal Science**. 13; 189-195.

CHAPTER V

EXPERIMENT III

EFFECT OF SYNBIOTIC IN CREEP FEED ON PRODUCTIVE PERFORMANCE, HEMATOLOGICAL TRAITS AND NUTRIEN DIGESTIBILITY OF GOAT KIDS

5.1 Abstract

The objectives of this study was to determine an optimal dose of inulin supplementation to enhance future investigating the effects on parameters associated with performance, immune modulation, or health status in goat kids and other adolescent ruminants. Inulin from Jerusalem artichoke and probiotic were used at w/w ratio 1 : 9 as the sources of prebiotic and probiotic, respectively. Twenty goat kid crossbreds (Thai native × anglo-nubian) during the experimental period, were given only milk on days 1-30, thereafter, days 31-75, they were fed with concentrate and roughage, and amount of milk decreased until weaned, and days 76-90, goats were only concentrate and roughage or each. Were assigned in a randomized block design into five groups of four animals each and were fed colostrum for 5 days before start of the experiment. There were five dietary treatments groups; control diet (T1), are synbiotic supplemented at 0.01% (T2), 0.02% (T3), 0.03% (T4) and 0.04% (T5) of diet (DM), respectively. The results showed that final body weight, all treatment groups

supplementation of synbiotics have a higher trend ($p<0.06$). Moreover, lactic acid bacteria during receiving diets (days 42, 56 and 84) were significantly different ($p<0.05$) among dietary treatments. Furthermore, using synbiotics at four supplement levels significantly increased percentages of phagocyte activity and index of phagocyte activity (IPA) at 56, 70 and 84 day was significantly increased ($p<0.05$). Utilization of organic metter, neutral detergent fiber and nitrogen absorption were significantly different ($p<0.05$). However, total VFA and propionic acid was significantly decreased ($p<0.05$). While, acitic acid, ratios of C_2 : C_3 and methane was significantly decreased ($p<0.05$). However, sex was not found to affect experimental.

Keywords : Goat kid, Synbiotic, Productive performance, Fecal characteristics, Jerusalem artichoke and Ruminant.

5.2 Introduction

Synbiotics are type of a feed additive that contains both a probiotic and prebiotic that work together to improve the microflora of the digestive tract of animals. The use of natural prophylactic supplements for animal has received a great deal of attention in the past decade. Synbiotics are an essential part of maintaining overall gastrointestinal health through stimulation of bacterial growth, inhibition of pathogens, and nourishment of probiotics. The United Nations Food and Agriculture Organization (FAO) recommend that the word “synbiotic” be used only if the net health benefit is synergistic (Cecic and Chingwaru, 2010).

The utilization of antibiotic restricted in animal feed, thereby the use of prebiotic which affecting not only animal health. However, prebiotic is important in gastroenterology, because prebiotic can have similar effect to antibiotic. Use of

prebiotics allows the probiotic thrive and prevails the pathogens. At present in case use prebiotic with probiotic was safe and effective. Use of prebiotics with probiotics known as synbiotic, the probiotic will thrive than add only probiotic because they are sub serve together and more probiotic pass to intestinal (Wanaporn, 2014). This research has purpose for study usage prebiotic with probiotic for increase the carcass quality and meat quality. Synbiotic are a combination of probiotics and prebiotics (Ashraf et. al., 2013) that can improves the survival of probiotic organisms because there processes substrate is available for fermentation. This could result in advantages to the host through increases availability of the live microorganisms. The combination of a prebiotic and probiotic in one product has been shown to confer benefits beyond those of either and it may be the specific use of synbiotics that beneficially affects the host by improving the survival of beneficial microflola. Studies on the application of probiotics in ruminants have been performed in the pre-ruminant's life and in adult ruminants, considering both the health status of the animals (reduction of incidence/severity of diarrhoea, carriage of pathogenic microorganisms) and the economic parameters. Mostly, applications have been addressed to cows and calves whereas less information is available for lambs, ewes and goats (Francesca et al., 2010). A way of potentiating the efficacy of probiotic preparations of live microbial dietary supplements in the gastrointestinal tract. The purpose of this study synbiotics for increase the productive performance and immune modulation of goat kids.

5.3 Objective

The objective of this experiment was to investigate the effects of synbiotic in ceerp feed on productive performance and immune modulation of goat kid.

5.4 Materials and methods

5.4.1 Animals and treatments

Twenty goat kid crossbreds (Thai native × anglo-nubian), were selected with regard to sex (10 male, 10 female), and fed colostrum for 5 days before start the experiment. During the experimental period, goat kids received, only milk for days 1-30 (stage 1), thereafter, day 31-75 (stage 2), they were fed concentrate and roughage, and decreased amounts of milk until weaned. During the final stage (stage 3) of the experiment, days 76-90, they were fed only concentrate and roughage. The experimental treatments were as follows :

Treament 1 : control diet

Treament 2 : supplemented with synbiotic at 0.01% of DM

Treament 3 : supplemented with synbiotic at 0.02% of DM

Treament 4 : supplemented with synbiotic at 0.03% of DM

Treament 5 : supplemented with synbiotic at 0.04% of DM

Is used inulin from Jerusalem artichoke (*Helianthus tuberosus* L.) is prebiotic source. The head cut into thin strips and then baked at a temperature of 60°C for 72 hours. Before grounding to be powder to do the experiment and microorganisms needed to gastrointestinal and with probiotic were used at ratio 1 : 9 (w/w) at the sources of prebiotic and probiotic, respectively.

5.4.2 Sample collection and analysis

5.4.2.1 Chemical analysis

Each subsample was dried to determine DM content, then grounded to pass through a 1 mm mesh screen and analyzed for chemical composition. Total N was determined using the Kjeldahl method and crude protein (CP) was

calculated by multiplying the N content by 6.25. Ether extract (EE) and ash contents were quantified by AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) determined by the methods described by Goering and van Soest (1970).

5.4.2.2 Complete blood count analysis

Blood collection was performed at the day 0, 28, 50 and 84 according to Kara et al. (2012). Five ml of blood from cephalic vein was divided into three tubes as the following (Weir, 1978). One ml of blood samples was collected into a micro-centrifuge tube with containing EDTA for complete blood count (CBC, RBC, hemoglobin, hematocrit, total white blood cell, neutrophil, basophil, lymphocyte and monocyte) determination. One ml of blood samples was collected into heparinzed polypropylene (PP) tubes for determination of plasma cholesterol. Another 3 ml of blood samples was collected into heparinzed polypropylene (PP) tubes and placed on ice then centrifuged at 1500 x g for 10 minutes at room temperature for determination of the percentage of phagocyte activity using the method modified from Weir (1978) as follows : 30 µl of *Escherichia coli* (stain ATCC 25922) (1-2 x 107 micro-organism/ml) and 30 µl of serum are combined and incubated at 37°C under continued rotation (4 rev./min) for 0, 15, 30 and 60 min, respectively. Next, cell are fixed with methanol and stranded with Geimsa stain. The percentage of cell that have ingested bacteria is determined from counts of at least 100 phagocytic cell as according to the following formula;

$$\% \text{ of phagocytic activity} = \left[\frac{\text{No. of phagocyte cell have in gested bacteria}}{\text{Total of phagocyte}} \right] \times 100$$

$$\text{Index of phagocyte activity} = \frac{\text{No. of ingested bacteria by phagocyte cell 100 cells}}{100}$$

5.4.2.3 Faecal sampling

Fecal sample was collected on day 0, 14, 28, 42, 56, 70 and 84 in the morning. Total stools of each goat kid were removed from the floor of the pen and kept at 4°C for bacterial enumeration. Microbiological analyses were as follows. Enumeration of mesophilic lactic acid bacteria (ISO 15214, 1998). The plating was performed into MRS medium (de Man, Rogosa and Sharpe. Difco®) from the prepared (10-1 to 10-3) by a duplicated pour plate method. The colonies were counted after incubation at 37°C for 48 hours under anaerobic conditions by double-layer MRS medium (ISO 15214, 1998). The dishes containing 15 to 30 colonies were examined. The calculation of mesophilic lactic acid bacteria were done as follows. General case. Calculations of APC was done according to the following formula

$$N = \frac{\Sigma C}{[(n1 \times 1) + (n2 \times 0.1)] \times (d)}$$

Where

N = Number of colonies per gram of product

∑c = Sum of all colonies on all plate counted

n1 = Number of plates in first dilution counted

n2 = Number of plates in second dilution counted

d = Dilution from which the first count were obtained

Estimation of low numbers. If the two dishes contained less than 15 colonies, the formula was simplified and only the arithmetical mean was used for calculation;

$$N = \frac{y}{d}$$

y = arithmetical mean of the colonies counted on two dished

d = the dilution factor of the initial suspension

If the two dished did not contain any colonies, the results are to be expressed as follows

- Less than 1/d aerobic bacteria per gram where d is the dilution factor of the initial suspension.

Enumeration of *Escherichia coli* (ISO-4831, 1991). The total numbers of *Escherichia coli* was determined by the three tubes most probable number (MPN). Lauryl Sulphate Tryptose broth (LTB) was used as selective enrichment medium. Brilliant Green Lactose Bile Broth (BGLB) and EC-medium were used as confirmation medium. The number of tubes that showed gas formation in the BGLB and EC-confirmation-broth was counted. The probable number of *Escherichia coli* were calculated according to the MPN tables (de Man, J.C. MPN tables. ISO 4831.1991).

Faecal score : Faecal samples was collected from each kid by retrieval from the rectum on the day 0, 14, 28, 42, 56, 70 and 84 at 07.00 h according to Kara et al. (2012). Faecal samples was scored with regard to consistency by the same researcher on all collection days according to the following system: 1 = watery, diarrhoea; 2 = soft, unformed; 3 = soft, formed; 4 = hard, formed and 5 = hard, dry pellets. Faecal pH was measured immediately following the collections. An electronic pH meter (PT-10, Sartorius AG, Goettingen, Germany) fitted with a glass electrode was used to determine faecal pH. Each faecal sample was placed in a 50 ml beaker and diluted 10-fold with distilled water as described by Verlinden et al. (2006). The mixture of faecal sample and distilled water was homogenized and pH was measured.

Fecal samples was collected and weighed during the last 7 days of each period. The fecal samples were collected about 5% of total fresh weight and divided into two parts, the first part being analyzed for DM, the second part kept for chemical analysis at the end of each period.

Concentrates and roughages was sampled daily during the collection period and were composted by period prior to analysis. During the last 7 days of each period, feed samples was collected every day and divided into two parts, the first part being analyzed for DM, while the second part kept and pooled at the end of each period for chemical analysis. Samples were dried at 60°C and ground (1 mm screen using Cyclotech Mill, Tecator, Sweden) and then analyzed for DM, OM, ash and CP content (AOAC, 1990), NDF, ADF (Goering and Van Soest, 1970).

5.4.2.4 Urine sampling

Total urine was collected on the same day with feces by using plastic container within drop of concentrate sulfuric acid (10%) to avoid nitrogen losing. The urinary samples were collected about 10% of volume and kept in refrigerator and pooled at the end of period to analyze for NH_3-N by Beecher and Whitton, (1965) for determining nitrogen balance.

5.4.2.5 Metabolism trial

Metabolism trial of 7 days collection was conducted for nutrient utilization in goats. The metabolic cages were specially designed with a facility for separate collection of feces and urine. The animals were kept in metabolic cages for 3 days, prior to actual collection of 7 days to acclimatize the animals to the new surroundings. The appropriate aliquots of feed offered, residue left, feces were preserved animal wise for the day for chemical analysis. Body weight of the animals

was recorded before and after the metabolism trials. Measurement data of feed offer and residue were obtained.

5.4.3 Statistical analysis

All data was statistically analyzed according to a Randomized Complete Block Design (RCBD). Significant differences between treatments were determined using Duncan's News Multiple Range Test (DMRT) and Trend analysis by SAS (1996).

5.4.4 Experimental period

The experiment was from November, 2015 to August, 2016.

5.5 Results and discussions

5.5.1 Feed chemical composition

All animals received a diet composing of whole plant silage plus concentrate. The diet was adequate to meet the requirements of crude protein, growth net energy, and dry mater intakes of the goats under the condition of maintenance plus lower activity and 50 g/d weight gain (Nutrient analyses of the feeds were performed according to the Association of Official Analytical Chemists (AOAC, 1995). Contained the main ingredients; ground corn grain, penut meal, repseed meal, coconut meal, wheat bran, rice bram, leucaena, cassava ship, corn gluten meal, sunflower meal, barley, molasses, vegetable oil, mineral and vitamin mix, limestone, salt.) (CP-NUMBER 991-18, as to the concentrate, it contained CP 18.0%, fat 3.0%, fiber 9.0% and moisture 13%), the analysis of milk composition it contained of fat 3.63%, protein 3.42%, lactose 4.74%, Ash 0.71% and moisture 87.5%, and examine the viability of bacteria in feed ingredients (Table 5.5.2).

Table 5.1 Nutrient compositions of starter concentrate and pangola hay on a dry matter basis[1].

Item (%)	Concentrate[2]	Pangola hay	Jerusalem artichoke
Dry matter	90.04	85.82	90.25
		%	
Crude protein	19.76	7.24	7.52
Organic matter	91.76	90.75	98.98
NDF	23.74	61.72	13.84
ADF	12.14	42.37	8.39
Ether extract	5.16	1.92	0.97
Acid insoluble ash	8.24	9.25	1.02
Inulin (g/100g)[3]			61.68

[1]Nutrient analyses of the feeds were performed according to the Association of Official Analytical Chemists (AOAC, 1995). [2]Contained the main ingredients; ground corn grain, peanut meal, rape seed meal, coconut meal, wheat bran, rice bran, leucaena, cassava ship, corn gluten meal, sunflower meal, barley, molasses, vegetable oil, mineral and vitamin mix, limestone, salt. [3]Inulin (g/100g dry weight). NDE = Neutral detergent fiber, ADF = Acid detergent fiber.

Table 5.2 The analysis microbial in diet of goat kids[1].

Items	Synbiotic levels in rations (%)					Analytical methods
	T1	T2	T3	T4	T5	
Bacillus spp. (cfu/g)	1.3×10^5	2.6×10^5	4.1×10^5	5.3×10^5	7.5×10^5	In house method: WI 18A-1 based on health protection agency national standard method F15 : (ISO/IEC 17025:2005)
Mesophilic LAB (cfu/g)	$<10^1$	$<10^1$	5.6×10^3	6.7×10^5	1.4×10^6	ISO 15214 : 1998
Yeats (cfu/g)	$<10^2$	$<10^2$	6.3×10^2	2.4×10^4	1.1×10^5	ISO 21527-2 :2008
Enterococcus spp. (cfu/g)	$<10^1$	$<10^1$	3.9×10^4	6.2×10^5	1.2×10^6	In house method: WI 18A-8 based on compendium of methods for the microbiological examination of foods : 4th ed., 2001, chapter 9
Presumptiv *Escherichia coli* (MPN/day)	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	ISO 7251 : 2005
Salmonella spp.*	-	-	-	-	-	ISO 6579 : 2002

[1]Sampling for analysis 25g per packed in plastic bag 1 kg, * = not detected in 25 g of sample, control diet (T1), synbiotic supplemented 0.01% of DM (T2), 0.02% of DM (T3), 0.03% (T4) and 0.04% of DM (T5), MPN = most probable number of coliform organisms (*Escherichia coli*) obtain three most probable number table/100 ml and cfu = colony forming unit.

5.5.2 Productive performance and fecal characteristics

Final body weight were recorded as; 17.50 kg (T1) 19.81 kg (T2), 20.39 kg (T3) 20.40 kg (T4) and 20.52 kg (T5), results showed that to all treatment groups supplementation of synbiotics have a higher trend (linear, $p<0.06$). It is postulated that increase in body weight might be due to increases fermentation in the small intestine followed by increases flow of microbial nitrogen at astronomically immense intestine, stable microflora composition at rumen, minute and astronomically immense intestine of calves (Verdonk et al., 1998). However, the increase of ADG and the decrease of FCR can also indicate improves ability of diets to better increase body weight. Synbiotics give more added substance benefits in development execution; sustain transformation proportion, hematological and biochemical parameters than probiotic and prebiotic singular utilization of these added substances (Abdel-Fattah and Fararh, 2009).

The results showed that fecal score not significantly. Lactic acid bacteria at 42 were recorded as; 4.90 (T1), 6.12 (T2), 6.08 (T3), 6.00 (T4) and 6.45 (T5) $\log_{10}$/g, 84 day; 5.23 (T1), 5.62 (T2), 5.73 (T3), 5.78 (T4) and 6.05 (T5) $\log_{10}$/g) was significantly increased ($p<0.05$), meanwhile there was no increase in *Escherichia coli* among dietary treatments. Synbiotic supplementation increases nutrients available to helpful microorganisms in the body. This increases the number and activity of these life forms in the gut and enhances the survival rate of probiotics amid their position of the digestive tract section through the stomach related tract. To control the measure of microscopic organisms as a punishment, adhering to demoralize rivalry or catch surface and enhances intestinal microbial equalization inside. However, the gastrointestinal tract is a vital protective system and the biggest safeguard shielding the host from poisons, pathogens and consequent inflammation while permitting commensal microorganisms to develop

(Medzhitov and Janeway, 2000). The prebiotics in the synbiotic blend enhance the survival of the probiotic microorganisms in the intestinal tract, and improves the action of the host's endogenous microbes (Vandenplas et al., 2013; Boirivant and Strober, 2007). While, there was less effect on growth performance and fecal *Escherichia coli* counts in calves fed synbiotic (Toshiya et al., 2011), the decreases in microorganisms was to be faulted such as Clostridium and *Escherichia coli* makes measure of smelling salts in the intestinal tract and in the blood diminished have the impact of hindering cancer-causing agents. Fat amalgamation in the liver subsequently, lipid and cholesterol in the blood diminished. (Schijver, 2001; Kaur and Gupta, 2002), Swanson and Fahey (2002) said key part of Bifidobacteria and Lactobacilli have chemicals disintegrate proteins bunch azoreductase nitroductas nitrate reductase and β-glucuronides low the protein causes these poisons. Additionally, synbiotic supplementation keeps population non-beneficial or potentially pathogenic microbes such as *Escherchia coli* at moderately low levels in the cecum digesta and small intestine (Abdel-Raheem et al., 2012). The gastrointestinal tract has a compound group of microbiota that gives advantages to its host in various diverse ways, including drug digestion; supplement creation, protection against pathogens, detoxification and control of the immune system. Creature contemplates have exhibited that adjustments in these gut microbial groups can bring about safe dysregulation; enhance development and impact on execution and there are data that supports the utilization of probiotics and prebiotics and particularly synbiotic. The synbiotic ideas about component of activity : changing the organization of intestinal microbiota by feasible advantage life form and non-absorbable living being substrates (Hozan Jalil Hamasalim, 2016).

Table 5.3 The effects of synbiotic supplementation on productive performance of goat kids.

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn.0.04%)*			trt	A	B	C	D
Initial weight (kg)	4.38	3.93	4.05	3.73	3.79	0.10	0.275	ns	ns	ns	ns	ns
Final weight (kg)	17.50	19.81	20.39	20.40	20.52	0.59	0.069	ns	*	ns	ns	ns
Increase weight (kg)	13.03^{a}	15.88^{ab}	16.34^{ab}	16.68^{ab}	16.73^{b}	0.46	0.023	*	*	ns	ns	ns
Feed intake; 30 day (g)	696.67	696.67	696.67	696.67	696.67	0.00	1.000	ns	ns	ns	ns	ns
Feed intake; 75 day (g)	657.89	656.39	653.22	654.03	650.81	0.89	0.239	ns	ns	ns	ns	ns
Feed intake; 90 day (g)	543.13	547.68	549.73	543.93	551.96	1.06	0.125	ns	ns	ns	ns	ns
ADG 30 day(g/day)	154.58	145.83	137.92	167.92	137.93	7.36	0.296	ns	ns	ns	ns	ns
ADG 75 day(g/day)	127.22	194.72	214.17	178.06	206.39	8.73	0.211	ns	ns	ns	ns	ns
ADG 90 day(g/day)	184.17	182.50	170.83	214.67	220.00	13.26	0.492	ns	ns	ns	ns	ns

^{a,b,c} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A = linear, B = quadratic, C = cubic, D = quartic, ADG = average daily gain, and SEM = standard error of mean.

Table 5.4 The effects of synbiotic supplementation on fecal score and fecal pH of goat kids.

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Fecal score[1]												
0 day	2.00	2.00	2.00	2.50	2.25	0.17	0.941	ns	ns	ns	ns	ns
14 day	2.50	3.00	2.75	3.25	3.00	0.10	0.482	ns	ns	ns	ns	ns
28 day	2.75	3.00	2.75	3.00	3.00	0.07	0.621	ns	ns	ns	ns	ns
42 day	2.75	2.75	3.00	3.25	3.25	0.10	0.288	ns	ns	ns	ns	ns
56 day	4.00	4.00	4.25	4.25	5.00	0.12	0.354	ns	ns	ns	ns	ns
70 day	4.25	4.25	4.50	5.00	5.00	0.10	0.652	ns	ns	ns	ns	ns
84 day	4.75	5.00	5.00	5.00	5.00	0.05	0.177	ns	ns	ns	ns	ns
Fecal pH	7.33	7.26	7.02	6.98	7.02	0.02	0.274	ns	ns	ns	ns	ns

[a,b] Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A = linear, B = quadratic, C = cubic, D = quartic. [1]Fecal scoring system; 1 = watery, diarrhoea; 2 = soft, unformed; 3 = soft, formed; 4 = hard, formed; and 5 = hard, dry pellets, and SEM = Standard error of mean.

Table 5.5 The effects of synbiotic supplementation on fecal bacterial populations of goat kids.

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Fecal bacteria population[2]												
***Escherichia coli* (MPN)**												
0 day	4.88	4.85	4.80	4.88	4.88	0.09	0.681	ns	ns	ns	ns	ns
14 day	4.73	5.50	6.43	6.68	6.45	0.25	0.718	ns	ns	ns	ns	ns
28 day	5.12	5.88	5.75	6.00	5.90	0.17	0.663	ns	ns	ns	ns	ns
42 day	4.90	6.13	6.08	6.00	6.45	0.11	0.196	ns	ns	ns	ns	ns
56 day	4.90	5.60	5.90	5.92	6.287	0.11	0.218	ns	ns	ns	ns	ns
70 day	5.05	6.00	6.08	6.08	6.25	0.15	0.441	ns	ns	ns	ns	ns
84 day	5.23	5.40	5.20	5.75	5.28	0.48	0.903	ns	ns	ns	ns	ns

Table 5.5 The effects of synbiotic supplementation on fecal bacterial populations of goat kids (Continued).

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Lactic acid bacteria (log_{10}/g)												
0 day	6.23	4.55	6.10	4.23	4.25	1.57	0.709	ns	ns	ns	ns	ns
14 day	4.23	5.50	5.93	6.93	6.43	0.75	0.097	ns	ns	ns	ns	ns
28 day	4.75	5.75	5.65	5.68	5.88	0.65	0.512	ns	ns	ns	ns	ns
42 day	4.90[a]	6.12[b]	6.08[b]	6.00[b]	6.45[b]	0.50	0.022	*	ns	ns	*	ns
56 day	4.90	5.60	5.90	5.92	6.27	0.70	0.069	ns	*	ns	ns	ns
70 day	5.05	6.00	6.08	6.08	6.25	0.46	0.135	ns	ns	ns	ns	ns
84 day	5.23[a]	5.62[ab]	5.73[ab]	5.78[b]	6.08[b]	0.48	0.042	*	*	ns	ns	ns
Total bacteria (log_{10}/g)	6.26	5.84	5.34	5.29	6.04	0.12	0.722	ns	ns	ns	ns	ns

[a,b] Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A = linear, B = quadratic, C = cubic, D = quartic. [2]Bacterial populations in sterile feces sampled from a subset (n = 10) of healthy kids in each group on day 14, 28, 42, 56, 70 and 84, MPN = most probable number of coliform organisms (*Escherichia coli*) obtain three most probable number table/100 ml, log_{10} = a logarithm to the base 10 and SEM = Standard error of mean.

5.5.3 Plasma cholesterol, hematological traits and phagocytic activity

The results in Table 4 show that plasma cholesterol and hematological traits (WBC, RBC, hemoglobin, hematocrit, lymphocyte, neutrophils, monocyte, eosinophil, basophil and platelet count) were not different ($p>0.05$) among dietary treatments. Among the hematological and biochemical parameters assessed in creature after medicines with synbiotic find triglyceride, cholesterol, high-thickness protein cholesterol, low-thickness protein cholesterol, egg whites, globulin, add up to serum protein, glucose and hematocrit (Hozan Jalil Hamasalim, 2016). Likewise, for use fed on diet contacting probiotics and prebiotics free was a significant decrease of the level of total cholesterol and as increases HDL-cholesterol (Farinu et al., 2004). However, mean estimates of each hematological trait were within reference ranges (Jackson and Cockcroft, 2002) in both CG and EG. Be that as it may, grown-up pooches supplemented with MOS had a higher lymphocyte fixation than control mutts in their study. The increases in blood lymphocytes might be valuable in providing protection against pathogens, though the decline in blood neutrophil fixation might be a negative result of sustaining prebiotics as neutrophils have a key part in the primary line of safeguard against pathogens (Davis et al., 2004). Nonetheless, hemoglobin level in blood of all calves was comparative toward the start of analysis though hemoglobin level in 56 day in calves that got inulin in sum 3 g/day/head was higher than in calves from others bunches. Hematocrit level both at starting and toward the end of analysis in calves from all gatherings was comparable (Babara, 2011).

For the test period, the results of this experiment analyzed the percentages of phagocyte activity (%PA), the index of phagocyte activity (IPA), and the number of engulfed *Escherichia coli* (strain ATCC 25922). It was found that

percentages of phagocytic activity at 42, 56, 70 and 84 days was significantly increased ($p<0.05$), among dietary treatments, and that IPA at 56 and 70 day was significantly increased ($p<0.05$) among dietary treatments. The results of this trial demonstrated that the rates of phagocyte movement (%PA) action of the goat kids supplemented of synbiotic (Table 5.7). These results showed that using the trial, the goat kid supplemented with synbiotic with 0.03% of DM had the best percentages of phagocytic activity, which corresponds to the higher index of phagocytic activity there is a for all groups supplemented with synbiotics. Because, a measure of phagocytic movement controlled by tallying the quantity of microorganisms ingested per phagocyte amid a constrained period hatching of a suspension of microscopic organisms and phagocytes in serum. These rates of the trial were likewise more noteworthy than the rates at the test. In the present review, the percentages of phagocytic activity increment as the Lactic acid bacteria numbers increment it is conceivable that there is certain relationship between the quantity of Lactic acid bacteria and percentages of phagocytic activity. The phagocytosis of microorganisms is to one of the nonspecific protection methods of essential significance for the host. The monocyte/macrophage cell lines, usually called processional phagocytes, can kill, overwhelm and pulverize particles, including irresistible operators, and possess a high phagocytic potential (Aderem and Underhill, 1999). In this regard, these cells have been as frequently assessed for phagocytic and lytic limit against pathogenic microorganisms. Because, innate immune replication constitutes the first line of prevent against invading pathogens, phagocytosis is a component of innate immune response and is, consequently, essential for organism health. Phagocytes activity involves kinetics processes in response to chemotactic stimulus, adhesion, eradication and removal of digested particles. Failure in the

phagocytic activity leads to immune deficiencies than can include chronic and recurring infections (Lehmann et al., 2000 and Dinauer, 2005). The results of Verlinden et al. (2006) show phagocytic activity (PA) of polymorph nuclear and mononuclear blood leukocytes from sheep and goats was quantified utilizing two variants of inert particles ingestion. This data can be uses determine the optimal dose and timing of probiotics and prebiotics supplementation in further studies investigating the effects of synbiotics on parameters associated with performance and immune modulation or health status in kids and other adolescent ruminants.

Table 5.6 The effects of synbiotic supplementation on plasma cholesterol, hematological traits of goat kids.

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Plasma cholesterol (mg/dl)												
0 day	151.25	149.43	149.61	149.86	141.21	6.36	0.489	ns	ns	ns	ns	ns
28 day	149.63	149.24	150.21	149.55	152.04	10.12	0.898	ns	ns	ns	ns	ns
56 day	145.15	149.43	149.61	149.85	151.25	7.43	0.518	ns	ns	ns	ns	ns
84 day	147.34	147.46	150.12	151.24	151.27	8.76	0.117	ns	ns	ns	ns	ns
White blood cell (WBC), 10^4/µl												
0 day	1.67	1.84	1.41	1.81	1.82	0.69	0.837	ns	ns	ns	ns	ns
28 day	1.91	2.25	2.11	1.97	1.87	0.59	0.865	ns	ns	ns	ns	ns
56 day	2.17	2.11	2.32	2.34	2.08	0.74	0.754	ns	ns	ns	ns	ns
84 day	3.03	2.81	2.84	2.76	2.69	0.67	0.582	ns	ns	ns	ns	ns

Table 5.6 The effects of synbiotic supplementation on plasma cholesterol, hematological traits of goat kids (Continued).

Items	Synbioticlevels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Lymphocytes, %/µl												
0 day	49.47	54.68	53.39	55.50	56.82	4.93	0.312	ns	ns	ns	ns	ns
28 day	52.50	53.25	49.25	56.75	60.26	5.91	0.722	ns	ns	ns	ns	ns
56 day	47.75	54.25	60.05	52.50	55.25	6.51	0.476	ns	ns	ns	ns	ns
84 day	51.34	51.22	53.46	55.52	57.41	3.74	0.746	ns	ns	ns	ns	ns
Neutrophils, %/µl												
0 day	35.25	34.50	35.50	35.75	34.75	2.37	0.883	ns	ns	ns	ns	ns
28 day	46.54	47.00	49.25	46.17	43.11	4.80	0.495	ns	ns	ns	ns	ns
56 day	44.11	43.18	44.21	42.97	42.25	3.51	0.537	ns	ns	ns	ns	ns
84 day	45.34^{a}	44.93^{a}	44.47^{ab}	43.50^{b}	43.55^{b}	2.83	0.036	*	*	ns	ns	ns
Monocytes, %/µl												
0 day	1.32	1.37	1.25	1.31	1.28	0.12	0.784	ns	ns	ns	ns	ns
28 day	1.58	1.72	1.53	1.84	2.04	0.54	0.412	ns	ns	ns	ns	ns
56 day	2.63	3.25	3.74	3.25	3.75	1.33	0.460	ns	ns	ns	ns	ns
84 day	3.76	2.25	3.50	2.25	2.75	1.16	0.082	ns	ns	ns	ns	ns

Table 5.6 The effects of synbiotic supplementation on plasma cholesterol, hematological traits of goat kids (Continued).

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Eosinophils, %/µl												
0 day	1.62	1.82	1.85	1.71	1.48	0.05	0.174	ns	ns	ns	ns	ns
28 day	2.64	2.58	2.75	3.04	3.04	0.06	0.326	ns	ns	ns	ns	ns
56 day	4.34	4.37	4.51	4.74	4.65	0.11	0.481	ns	ns	ns	ns	ns
84 day	4.53	4.57	4.52	4.55	4.57	0.38	0. 374	ns	ns	ns	ns	ns
Red blood cell (RBC), 10^6/µl												
0 day	8.32	8.36	8.12	7.49	7.78	0.76	0.519	ns	ns	ns	ns	ns
28 day	8.24	7.84	8.57	8.13	8.37	0.98	0.948	ns	ns	ns	ns	ns
56 day	8.34	7.89	8.00	8.40	8.26	0.81	0.818	ns	ns	ns	ns	ns
84 day	7.82	9.01	8.41	8.94	8.86	0.44	0.184	ns	ns	ns	ns	ns

Table 5.6 The effects of synbiotic supplementation on plasma cholesterol, hematological traits of goat kids (Continued).

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Hemoglobin, g/dl												
0 day	7.70	7.85	7.80	7.03	7.08	0.42	0.248	ns	ns	ns	ns	ns
28 day	8.10	8.77	8.08	8.42	8.35	0.51	0.596	ns	ns	ns	ns	ns
56 day	8.33	7.93	8.67	8.85	8.45	0.25	0.797	ns	ns	ns	ns	ns
84 day	8.80	9.07	8.63	9.20	9.45	0.27	0.866	ns	ns	ns	ns	ns
Hematocrit, %/µl												
0 day	20.18	21.15	20.45	19.53	19.75	0.35	0.517	ns	ns	ns	ns	ns
28 day	21.97	23.28	21.61	21.97	21.80	0.63	0.258	ns	ns	ns	ns	ns
56 day	22.87	23.15	22.80	23.18	23.92	0.67	0.731	ns	ns	ns	ns	ns
84 day	23.57	26.02	25.00	25.18	25.57	0.48	0.415	ns	ns	ns	ns	ns

[a,b] Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant ,control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A = linear, B= quadratic, C = cubic, D = quartic and SEM = standard error of mean.

Table 5.7 The effects of synbiotic supplementation on percentages of phagocyte activity (%PA) and index of phagocyte activity (IPA) of goat kids.

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Percentages of phagocyte activity (%PA)												
0 day	29.15	29.22	29.43	29.35	29.19	0.13	0.962	ns	ns	ns	ns	ns
14 day	29.66	30.06	29.96	30.09	30.27	0.16	0.421	ns	ns	ns	ns	ns
28 day	29.97	30.67	30.76	30.77	30.92	0.24	0.197	ns	ns	ns	ns	ns
42 day	30.71	31.35	31.71	32.43	32.48	0.17	0.066	ns	*	ns	ns	ns
56 day	30.91^{a}	31.12^{a}	31.58^{ab}	32.61^{b}	32.77^{b}	0.24	0.046	*	*	ns	ns	ns
70 day	30.03^{a}	30.97^{ab}	31.08^{ab}	31.53^{b}	31.56^{b}	0.14	0.025	*	*	ns	ns	ns
84 day	29.52^{a}	30.31^{ab}	30.40^{b}	30.98^{b}	31.22^{b}	0.29	0.024	*	*	ns	ns	ns

Table 5.7 The effects of synbiotic supplementation on percentages of phagocyte activity (%PA) and index of phagocyte activity (IPA) of goat kids (Continued).

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Index of phagocyte activity (IPA)												
0 day	4.11	4.21	3.92	4.12	4.20	0.06	0.768	ns	ns	ns	ns	ns
14 day	4.32	4.65	4.14	4.40	4.60	0.07	0.584	ns	ns	ns	ns	ns
28 day	3.49	4.37	4.18	4.30	4.46	0.08	0.451	ns	ns	ns	ns	ns
42 day	4.27	4.36	4.16	4.54	4.32	0.04	0.208	ns	ns	ns	ns	ns
56 day	3.85^{a}	4.43^{b}	4.11^{ab}	4.30^{b}	4.26^{ab}	0.06	0.044	*	ns	ns	*	ns
70 day	3.80^{a}	4.37^{b}	4.30^{ab}	4.18^{ab}	4.23^{ab}	0.07	0.021	*	ns	ns	*	ns
84 day	3.88	4.52	4.02	4.23	4.03	0.05	0.097	ns	ns	ns	ns	ns

^{a,b,c} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A = linear, B = quadratic, C = cubic, D = quartic and SEM = standard error of mean.

5.5.4 Dry matter intake, body weight change, nutrient digestibility, nitrogen utilization, ruminal ammonia, blood urea nitrogen and volatile fatty acid proportion

The results showed that nutrient digestibility no significantly, but ether extract were recorded as; 7.04 (T1), 7.04 (T2), 6.66 (T3), 6.58 (T4) and 6.51 (T5) g/day, results showed that the T2, T3 and T4 tretment group supplementation of inulin was significantly decrease ($p<0.05$). While, acicd detergent fider (ADF) were recorded as; 122.90 (T1), 123.41 (T2), 123.43 (T3), 123.45 (T4) and 124.38 (T5) g/day, results showed that was significan increased ($p<0.05$), specifically the synbiotic supplemante at 0.04% of DM (T5). Percantage of appearance digestibility found the utilization of organic metter (OM) and neutral detergent fider (NDF) were recorded as; 63.44 (T), 64.75 (T2), 67.07 (T3), 68.52 (T4) and 68.61 (T5); 71.60 (T1), 72.03 (T2), 73.03 (T3), 73.10 (T4) and 73.12 (T5) %, results showed that was significan increased ($p<0.05$), specifically the synbiotic supplemante at 0.03% and 0.04% of DM (T4,T5). And the study found of nitrogen absorption was significantly increased ($p<0.05$), is equal; 5.99 (T1), 6.10 (T2), 6.13 (T3), 6.30 (T4) and 6.36 (T5) g, specifically the synbiotic supplemante at 0.03% and 0.04% of DM (T4, T5). However, results showed that to all treatment groups supplementation of synbiotics have a higher trend (linear).This is due to synbiotics may be defined as a mixture of probiotics and prebiotics that beneficially affects the host by improving the survival and implantation of live microbial dietary supplements in the gastrointestinal tract and results on *in vivo* trials are promising, showing a synergistic effect coupling probiotics and prebiotics in the reduction of food-borne pathogenic bacterial populations (Gibson and Roberfroid, 1995; Bomba et al., 2002). Synbiotic could increase the digestibility and availability of many nutrient elements such as, vitamins, mineral elements and proteins (Nali et al., 2009). Mreover, supplemente of synbiotic in sheep and goat diet not effect on dry matter intake, daily

gain and feed convertion rate, and digestibility of dry matter, organic matter and crude protein were not affect with symbiotic supplementation, but digestibily of neutal detergent fiber improved significantly (Abd EI-Ghani, 2004; Kazemi-Bonchenari et al., 2013). While, Fayed (2001) who reported that digestibility coefficients of all nutrients of goats fed synbiotic were higher than in control animals.

Total volatile fatty acid 3 h post feeding were recorded as; 91.84 (T1), 93.64 (T2), 94.55 (T3), 96.06 (T4) and 96.01 (T5) mM/L, and 6 h post feeding were recorded as; 90.50 (T1) 92.35 (T2), 93.92 (T3), 95.48 (T4) and 95.85 (T5) mM/L, results showed that the all treatment group, supplementation of synbiotic was significantly increase ($p<0.05$). Volatile fatty acid proportion (acitic acid; C_2) all hour post feeding was significantly decrease ($p<0.05$), specifically all of group the synbiotic supplemante (Table 5.10). Propionic acid (C_3) at 6 h post feeding; 24.26 (T1), 25.53 (T2), 25.72 (T3), 28.34 (T4) and 28.57 (T5) %mol, result showed that the T4 and T5 treatment group, was significantly increase ($p<0.05$). Butyric acid (C_4) not significantly. While, ratios of $C_2 : C_3$ at all hour post feeding was significantly decrease ($p<0.05$) all group supplementation of synbiotic. And methane (CH_4) at 3 h post feeding; 26.60 (T1), 25.75 (T2), 25.51 (T3), 24.32 (T4) and 24.05 (T5), 6 h post feeding; 26.71 (T1), 25.75 (T2), 25.36 (T3), 23.77 (T4) and 23.60 (T5), results showed that the all tretment group supplementation of synbiotic, was significantly decrease ($p<0.05$). While, Umucalilar et al. (2010) reported the total VFA concentration quadratically decreased with increasing forage proportion and were associated with the increase of acetate proportion and the decreases of butyrate, because of its greater solubility and increased total VFA concentration in the rumen in response to inulin addition are in agreement with literature data focusing on colon fermentation (Rosendo et al., 2003; Dijkerman et al., 1997).

Table 5.8 The effects of synbiotic supplementation on nutrient digestibility and nitrogen utilization of goat kids.

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Nutrient intake, g/day												
Ogranic matter	364.51	369.84	366.61	370.35	366.80	0.82	0.098	ns	ns	ns	ns	ns
Crude protein	49.78	50.14	50.53	50.66	51.21	0.16	0.058	ns	*	ns	ns	ns
Ether extract	7.04^{a}	7.04^{a}	6.66^{b}	6.58^{b}	6.51^{b}	0.04	0.042	*	*	ns	ns	ns
Neutral detergent fiber	188.36	190.75	189.24	189.56	187.92	0.30	0.214	ns	ns	ns	ns	ns
Acid detergent fiber	122.90^{a}	123.41^{a}	123.43^{ab}	123.45^{ab}	124.38^{b}	0.18	0.028	*	ns	*	ns	ns
Appearance digestibility, %												
Ogranic matter	63.44^{a}	64.75^{a}	67.04^{b}	68.52^{c}	68.61^{c}	0.21	0.001	**	**	ns	ns	ns
Crude protein	75.09	75.23	76.42	77.53	77.69	0.32	0.131	ns	ns	ns	ns	ns
Ether extract	75.38	75.91	75.44	75.79	75.99	0.23	0.475	ns	ns	ns	ns	ns
Neutral detergent fiber	71.60^{a}	72.03^{ab}	73.03^{b}	73.10^{b}	73.12^{b}	0.15	0.026	*	*	ns	ns	ns
Acid detergent fiber	60.88	61.58	63.02	62.87	62.88	0.29	0.256	ns	ns	ns	ns	ns

Table 5.8 The effects of synbiotic supplementation on nutrient digestibility and nitrogen utilization of goat kids (Continued).

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Nitrogen utilization (g/day)												
Nitrogen intake	7.97	8.10	8.02	8.19	8.11	0.03	0.076	ns	ns	ns	ns	ns
Fecal nitrogen	1.26	1.29	1.31	1.33	1.32	0.01	0.696	ns	ns	ns	ns	ns
Urinal nitrogen	3.19	3.15	2.94	3.00	2.91	0.04	0.567	ns	ns	ns	ns	ns
N absorption (g)	5.99^{a}	6.10^{ab}	6.13^{ab}	6.30^{bc}	6.36^{c}	0.03	0.028	*	*	ns	ns	ns
N retention (g)	3.53	3.67	3.78	3.88	3.89	0.05	0.428	ns	ns	ns	ns	ns
N absorption (%)	75.13	75.27	76.46	77.57	77.73	0.31	0.118	ns	ns	ns	ns	ns
N retention (%)	44.23	45.25	47.09	47.29	47.92	0.60	0.623	ns	ns	ns	ns	ns

^{a,b,c} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A = linear, B = quadratic, C = cubic, D = quartic and SEM = standard error of mean.

Table 5.9 The effects of synbiotic supplementation on ruminal pH, ruminal ammonia nitrogen and blood urea nitrogen of goat kids.

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Ruminal pH												
0 h post feeding	7.07	6.99	7.05	7.04	7.04	0.02	0.197	ns	ns	ns	ns	ns
3 h post feeding	7.02	6.93	6.97	7.05	6.93	0.02	0.114	ns	ns	ns	ns	ns
6 h post feeding	7.04	6.95	6.98	7.02	7.05	0.02	0.475	ns	ns	ns	ns	ns
Ruminal NH_3-N (mg/dl)												
0 h post feeding	13.52	13.38	13.52	13.45	13.31	0.14	0.284	ns	ns	ns	ns	ns
3 h post feeding	15.90	15.83	16.04	16.11	16.39	0.06	0.084	ns	ns	ns	ns	ns
6 h post feeding	14.99	14.85	14.85	15.06	15.13	0.09	0.361	ns	ns	ns	ns	ns
Blood urea nitrogen (BUN) (mg/dl)												
0 h post feeding	13.25	15.00	14.50	15.00	15.00	0.50	0.524	ns	ns	ns	ns	ns
3 h post feeding	14.25	15.50	15.00	16.25	15.50	0.57	0.381	ns	ns	ns	ns	ns
6 h post feeding	15.25	15.75	15.75	16.00	16.50	0.43	0.094	ns	ns	ns	ns	ns

ns = non-significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A = linear, B = quadratic, C = cubic, D = quartic, NH_3-N = ammonia nitrogen, BUN = blood urea nitrogen and SEM = Standard error of mean.

Table 5.10 The effects of synbiotic supplementation on volatile fatty acid proportion of goat kids.

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Total volatile fatty acid (mM/L)												
0 h post feeding	90.29	90.75	92.64	94.53	94.89	0.39	0.069	ns	*	ns	ns	ns
3 h post feeding	91.84^{a}	93.64^{ab}	94.55^{b}	96.06^{b}	96.21^{b}	0.36	0.017	*	*	ns	ns	ns
6 h post feeding	90.50^{a}	92.35^{b}	93.92^{bc}	95.48^{cd}	95.85^{d}	0.22	0.020	*	*	ns	ns	ns
Volatile fatty acid proportion (%mol)												
Acitic acid (C_2)												
0 h post feeding	60.88^{a}	60.83^{a}	58.48^{b}	59.53^{ab}	59.54^{ab}	0.22	0.032	*	ns	*	ns	ns
3 h post feeding	61.38^{a}	59.52^{b}	59.34^{b}	58.69^{bc}	57.97^{c}	0.16	0.003	**	**	ns	ns	ns
6 h post feeding	61.60^{a}	59.39^{bc}	59.64^{b}	57.62^{c}	58.02^{c}	0.26	0.026	*	ns	ns	ns	*
Propionic acid (C_3)												
0 h post feeding	24.69	25.34	27.03	26.25	26.72	0.24	0.057	ns	ns	ns	*	ns
3 h post feeding	24.41	25.53	25.87	27.52	27.99	0.17	0.061	ns	*	ns	ns	ns
6 h post feeding	24.26^{a}	25.53^{ab}	25.72^{b}	28.34^{c}	28.57^{c}	0.18	0.047	*	*	ns	ns	ns

Table 5.10 The effects of synbiotic supplementation on volatile fatty acid proportion of goat kids (Continued).

Items	Synbiotic levels in rations (%)					SEM	P-value	Trent analysis				
	T1 *(Cont.)*	T2 *(Syn. 0.01%)*	T3 *(Syn. 0.02%)*	T4 *(Syn. 0.03%)*	T5 *(Syn. 0.04%)*			trt	A	B	C	D
Butyric acid (C_4)												
0 h post feeding	14.43	13.83	14.50	14.23	13.74	0.11	0.254	ns	ns	ns	ns	ns
3 h post feeding	14.22	14.95	14.98	13.05	14.52	0.19	0.501	ns	ns	ns	ns	ns
6 h post feeding	14.15	15.09	14.65	13.82	13.64	0.16	0.620	ns	ns	ns	ns	ns
Ratios of C_2 : C_3												
0 h post feeding	2.48^{a}	2.41^{ab}	2.17c	2.27^{abc}	2.23^{bc}	0.03	0.048	*	ns	*	ns	*
3 h post feeding	2.52^{a}	2.33^{b}	2.30^{b}	2.11^{c}	2.11^{c}	0.02	0.008	**	**	ns	ns	ns
6 h post feeding	2.55^{a}	2.33^{b}	2.32^{b}	2.05^{c}	2.02^{c}	0.03	0.003	**	**	ns	ns	ns
Methene (CH_4)												
0 h post feeding	26.38	25.94	24.68	25.26	24.94	0.17	0.244	ns	ns	ns	ns	ns
3 h post feeding	26.60^{a}	25.75^{b}	25.51^{b}	24.32^{c}	24.05^{c}	0.12	0.002	**	**	ns	ns	ns
6 h post feeding	26.71^{a}	25.75^{b}	25.36^{b}	23.77^{c}	23.60^{c}	0.14	0.009	**	**	ns	ns	ns

^{a,b,c} Means in row with different superscripts letter are significant differences ($p<0.05$), ns = non-significant, * = significant, ** = highly significant, control diet (T1), inulin extracted from Jerusalem artichoke supplemented 2% of DM (T2), 4% of DM (T3) and commercial inulin supplemented 2% of DM (T4), 4% of DM (T5), A = linear, B = quadratic, C = cubic, D = quartic, and SEM = standard error of mean.

5.6 Conclusions

The impact of synbiotic in creep feed is beneficial to hematological attributes of goat kids, resulting in improves production performance and fecal score. Specifically, synbiotics supplemented at 0.03% and 0.04% of DM, has been shown to enhance feed conversion ratio, average daily gains and final body weights. These improvements are likely to influence microbial populations and nuteint digestibility and volatile fatty acid proportion as well. Be that it may, various possible mechanisms of action probiotics have been suggested among which are the stimulation the production of antimicrobial substances, competition for adhesion to epithelial cells and stimulation of the immune system of affects the goat's good health.

5.7 References

Abd El-Fattah, F.A.I. and Fararh, K.M. (2009). Effect of dietary supplementation of probiotic, prebiotic and synbiotic on performance, carcass characteristics, blood picture and some biochemical parameters in broiler chickens. **Benha Veterinary Medical Journal**. 20: 9-23.

Abd El-Ghani, A.A. (2004). Influence of diet supplementation with yeast (Saccharomyces cerevisiae) on performance of Zaraibi goats. **Small Ruminant Research**. 52: 223-229.

Abd El-Raheem, S.M., Abd-Allah, S.M.S., and Hassanein, K.M.A. (2012). The Effects of prebiotic, probiotic and synbiotic supplementation on intestinal microbial ecology and histomorphology of broiler chickens. **International Journal for Agro Veterinary and Medical Sciences**. 6: 277-289.

Aderem, A., and Underhill, D.M. (1999). Mechanisms of phagocytosis in macrophages. **Annual Review of Immunology**. 17: 593-623.

AOAC. (1995). Official Method of Analysis. 16th ed. Association of Official Analytical Chemist, Washington, DC.

Babara, K. (2011). Effect of mannan-oligosaccharides, inulin and yeas nucleotides added to calf milk replacers on rumen microflora, level of serum immunoglobulin and health condition of calves. **Electronic Journal Polish Agricultural Universities**. 14(2): 18.

Boirivant, M., and Strober, W. (2007). The mechanism of action of probiotics. **Current Opinion in Gastroenterology**. 23: 670-692.

Cecic, A., and Chingwaru, W. (2010). The role of functional foods, Nutraceuticals, and Food Supplements in Intestinal Health. **Nutrients**. 2: 611-625.

Davis, M.E., Maxwell, C.V., Erf, G.F., Brown, D.C., and Wistuba, T.J. (2004). Dietary supplementation with phosphorylated mannans improves growth response and modulates immune function of weanling pigs. **Journal of Animal Science**. 82: 1882-1891.

Dinauer, M.C. (2005). Chronic granulomatous disease and other disorders of phagocyte function. **Hematology**. (1): 89-95.

Farinu, G.O., Ademola, S.G., Ajayi Obe, A.O., and Babatunde, G.M. (2004). Growth, haematological and biochemical studies on garlic and ginger-fed broiler chickens. **Moor Journal of Agricultural Research**. 5: 122-128.

Fayed, M.A. (2001). Effect of using yea-sacc on performance of sheep and goats in Sinai. **Egyptian Journal of Nutrition and Feeds**. 4: 67-80.

Francesca, G., Paola, M., and Bruno, B. (2010). Probiotics and prebiotics in animal feeding for safe food production. **International Journal of Food Microbiology**. 141: 15-28.

Hozan, J.H. (2016). Synbiotic as feed additives relating to animal health and performance. **Advances in Microbiology**. 6: 288-302.

ISO-4831. (1991). Microbiology-general guidance for enumeration of presumptive *Escherichia coli*-most probable number technique. 70-83.

ISO-15214. (1998). Microbiology of food animal feeding stuffs-horizontal method for the enumeration of mesophilic lactic acid bacteria-colony-count technique at 30 oC. Microbiology. 23-41.

Jackson, P.G.G., and Cockcroft, P.D. (2002). Normal physiological values. In **Clinical Examination of Farm Animals** (301 p). Oxford, UK; Wiley-Blackwell.

Kaur, N., and Gupta, A.K. (2002). Applications of inulin and oligofructose in health and nutrition. **Journal of Biological Science**. 27(7): 703-714.

Kazemi-Bonchenari, M., Ghasemi, H.A., Khodaei-Motlagh, M., Khaitabadi-Farahani, A.H., and Ilani, M. (2013). Influence of feeding synbiotic containing Enterococcus faecium and inulin on blood metabolites, nutrient digestibility and growth performance in sheep fed alfalfa-based diet. **Scientific Research and Essays**. 8(21): 853-857.

Lehmann, A.K., Sornes, S., and Halstensen, A. (2000). Phagocytosis: measurement by flow cytometry. **Journal of Immunological Methods**. 243 (1-2): 229-242.

Medzhitov, R., and Janeway, C. (2000). Innate Immunity. **The New England Journal of Medicine**. 343: 338-344.

Statistical Analysis System. (1996). SAS/STAT User's Guide: Statistics, Version 6.12 edition. SAS Inc., Cary, NC, USA.

Schijver, R.D. (2001). Dietary oligosaccharide supplements: Effects on digestion in pig. Digestive physiology of pig. Proc. Alltech's 8th Ann. Symp. Swedish University of Agricultiral Science. Press, Uppsala. 121-123.

Swanson, K.S., and Fahey, G.C. (2002). Prebiotics in companion animal nutrition. In T.P. Lyons and K.A. Jacques (eds.). **Biotechnology in the Feed Industry. Proc. Alltech's 18th Ann. Symp** (pp 461-473). Loughborough, UK; Nottingham University Press.

Toshiya, H., Kenji, K., Hirofumi, N., Toshiaki, M., Hiroyuki, K., Takashige, I., Kiyoshi, A., Kenji, Y., Fuminori, T., and Shiro, K. (2011). Effect of cellooligosaccharide or synbiotic feeding on growth performance, fecal condition and hormone concentrations in Holstein calves. **Journal of Animal Science**. 82: 543-548.

Vandenplas, Y., De Greef, E., Devreker, T., Veereman-Wauters, G., and Hauser, B. (2013). Probiotics and prebiotics in infants and children. **Current infectious disease reports**. 15: 251-262.

Verdonk, J.M.A.J., Beelan, G.M., Jansman, A.J.M., and Huismam, J. (1998). Effect of soya carbohydrate fraction on the ileal digestibility and endogenous flow of nitrogen in veal calves. In A.J.M. Jansman, G.D. Hill, J. Huisman and A.F.B. Vander Poel (eds.). **Recent Advances of Research in Antinutritional Factors in Legume Seeds** (pp 341-343). The Netharlands; Wageningen.

Verlinden, A., Hesta, M., Hermans, J.M., and Janssens, G.P.J. (2006). The effects of inulin supplementation of diets with or without hydrolyzed protein sources on digestibility, fecal characteristics, hematology, and immunoglobulins in dogs. **British Journal of Nutrition**. 96: 936-944.

Wanaporn, T. (2014). Alternatives to the use of antibiotics as growth promoters for livestock animals. **Journal of Agricultural**. 30(2): 201-212.

Weir, D.M. (1978). Handbook of experimental immunology. Vol.2 cellular immunology. 3rd Oxford; Blackwell scientific publication. 46.1-46.21.

CHAPTER VI

OVERALL CONCLUSION

6.1 Conclusions

The aim of this experiment was to study the effects of inulin extracted from Jerusalem artichoke, commercial inulin and synbiotic (combination of inulin extracted from Jerusalem artichoke with probiotic [BACTOSAC-P®]) on productive performance, immune modulation, or health status in goat kids.

The first experiment was carried out to investigate inulin in milk is beneficial to productive performance, hematological attributes of goat kids, resulting in production performance, fecal score. Specifically, inulin extracted from Jerusalem artichoke, supplemented at 2% of DM, has proven to enhance feed consumption, average daily gains and final body weights. These improvements are likely to influence microbial populations, phagocyte action, nutrient digestibility, and nitrogen utilization as will.

The second experiment was to investigate the effects of inulin in wet blanket is beneficial to hematological attributes of goat kids, resulting in production performance and fecal score. Specifically, inulin extracted from Jerusalem artichoke, supplemented at 2% DM, has proven to enhance feed consumption, average daily gains and final body weights. These improvements are to influence microbial populations, phagocyte action, nutrient digestion and nitrogen utilization and have the effect of decreasing ruminal ammonia nitrogen.

Be that as it may, various possible mechanisms of action probiotics have been suggested among which are the stimulation the production of antimicrobial substances, competition for adhesion to epithelial cells and stimulation of the immune system of affects the goat's good health. Additionally future research of prebiotic application in livestock should consider immunological aspects and livestock product quality therapeutic aspects with more emphasis on common gastrointestinal disorders.

The third experiment was to investigate the effects of of synbiotic in creep feed is beneficial to hematological attributes of goat kids, resulting in improves production performance and fecal score. Specifically, synbiotics supplemented at 0.03% of DM, has been shown to enhance feed conversion ratio, average daily gains and final body weights. These improvements are likely to influence microbial populations, phagocyte activity and nuteint digestibility as well.

Be that as it may, as far as creation costs, inulin from Jerusalem artichoke, under business inulin too. Different component of active probiotics have proven to be essential among which are; the incitement of host chemicals, creation of antimicrobial substances, rivalry for bond to epithelial cells, and incitement of the safe arrangement of the host and clear outcome of the studies is that the blood immune system and especially the immune cells associated with the Peyer's patches are responsive to a dietary supplement of inulin their metabolites. The mechanisms of inulin include indirect effects such as a shift in the composition of the intestinal flora and the enhanced engenderment of immune regulatory and perhaps other bacterial metabolites. However, supplementation of inulin may give a horse useful insusceptible adjustment status, and the utilization of inulin in animal engenderment, as a possible alternative to antimicrobial magnification promoters, has given contradictory results, while their

utilization in the modulation of the gut microbial equilibrium is worthwhile. They contribute to the establishment of a ‘healthier’ microbiota where *Bifidobacteria* or *lactobacilli* become predominant and exert possible health-promoting effects at the expense of more deleterious species.

BIOGRAPHY

Mr. Bhutharit Vittayaphattananurak Raksasiri was born on January 24, 1977 in Sisaket Province. I graduated Diploma's degree of Animal Science at Sisaket college of Agriculture and Technology in 1998, Bachelor's degree of Science in Industrial Education and Master's degree of Animal Science at King Mongkut's Institute of Technology Ladkrabang (KMITL) in 2000 and 2004, respectively. I worked in the Faculty of Animal Sciences and Agricultural Technology, Silpakorn University, Petchaburi Information Technology Campus, since 2001 until now, continued to study Doctor of Philosophy in Animal Production Technology, School of Animal Production Technology, Institute of Agricultural Technology, Suranaree University of Technology. I has been receiving a Research and Researcher for Industry (RRi) Ph.D. Scholarship (Code : PHD5610035), awarded by the Thailand Research Fund (TRF).