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# The effect of Sunphenon 30S-O on methane emission, nutrient intake, digestibility and rumen fermentation

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ABSTRACT

Sunphenon 30S-O is obtained from the leaves of traceable green tea (*Camellia sinensis*) and standardized for its catechin content (205 g/kg DM). This experiment was conducted to evaluate the effect of supplementation with different concentrations of Sunphenon 30S-O on methane emissions, nutrient intake, digestibility, protozoa abundance and the concentrations of volatile fatty acids (VFA) and ammonia-N ($NH_3$-N) in sheep. Four Corriedale wethers with an average body weight of $64.25 \pm 3.86$ kg were arranged in a $4 \times 4$ Latin square and fed a basal diet of Guinea grass (*Panicum maximum*) hay at the maintenance level with four different concentrations of Sunphenon 30S-O (0, 10, 25 and 40 g/Kg DM intake). The experiment was conducted over 84 days in four 21-day periods that consisted of 14 days of acclimatization, five days of measurement and two 24-h runs in open-circuit respiration chambers to measure gas exchange. A second study was also conducted using an *in vitro* continuous gas quantification system and *in vitro* digestion techniques. All of the data were subjected to polynomial regression analysis. Dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fibre (ADF) and gross energy (GE) intake all declined linearly ($P < 0.01$) and quadratically ($P < 0.05$) with increasing concentrations of Sunphenon 30S-O. Conversely, the apparent nutrient digestibility remained similar among treatments regardless of the concentration of Sunphenon 30S-O in the ration. *In vivo* methane emission (l/kg digestible OM intake) declined linearly ($P < 0.05$) by 7.4–13.5% with increasing concentrations of Sunphenon 30S-O, and a similar trend was observed in *in vitro* methane emissions. Urinary and methane energy decreased linearly ($P < 0.01$) from 17.4% to 11.2% and from 7.3% to 6.2% of the gross energy intake, respectively, with increasing supplement concentrations, and the *in vitro* VFA (mmol/L) and $NH_3$-N concentrations (mg/ml) were also reduced (linear $P < 0.01$; quadratic $P < 0.01$). The total abundance of the protozoa population also declined linearly and quadratically ($P < 0.01$), and the *in vitro* DM degradability (IVDMD) was reduced (linear $P < 0.01$; quadratic $P < 0.01$) with increasing concentrations of Sunphenon 30S-O. The findings of this study indicated that the addition of Sunphenon 30S-O reduced *in vivo* methane emissions without affecting total tract nutrient

*Abbreviations:* ADF, acid detergent fibre; CP, crude protein; CT, condensed tannin; DE, digestible energy; DM, dry matter; EC, epicatechin; ECG, epicatechin gallate; EE, ether extract; EGC, epigallocatechin; EGCG, epigallocatechin gallate; ER, energy retention; GE, gross energy; GHG, greenhouse gas; HP, heat production; IVDMD, *in vitro* dry matter degradability; IVOMD, *in vitro* organic matter degradability; ME, metabolizable energy; NDF, neutral detergent fibre; $NH_3$-N, ammonia-N; OM, organic matter; ORP, oxidation reduction potential; IVRCPD, *in vitro* rumen crude protein degradability; VFA, volatile fatty acid.

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digestibility, and energy and protein retention were not affected despite the reduction in total nutrient intake. Thus, to achieve optimum reduction of methane emissions and the concomitant saving of dietary energy without any negative impacts on total-tract digestibility and nutrient balance, Sunphenon 30S-O supplementation up to 40 g/kg DM could be an option.



## 1. Introduction

Climate change is one of the greatest obstacles facing the world today, and its association with the emission of greenhouse gases (GHGs), such as $CO_2$ and $CH_4$, is well known. While ruminants play an important role as an essential source of high-quality protein in human diets, they are also a major source of GHGs. According to FAO estimates (Opio et al., 2013), the greatest source of $CH_4$ in ruminant production is enteric fermentation, which accounts for approximately 47% of the sector's GHG emissions and more than 90% of total $CH_4$ emissions. As a GHG, $CH_4$ is 25 times stronger than $CO_2$ (Opio et al., 2013), and its effect will become more pronounced in the short term because ruminant production is increasing worldwide to meet an ever-increasing demand for milk and meat (Becker et al., 2013). Therefore, reducing $CH_4$ emissions from ruminant livestock will play a significant role in decreasing environmental pollution, provided that nutrient utilization efficiency is not affected. Modifying the composition of animal diets is often regarded as an option to minimize ruminal $CH_4$ emissions (Becker et al., 2013), and condensed tannin-containing legume forages (Animut et al., 2008 with 50–151 g CT/kg DM; Min et al., 2002b with 32 g CT/kg DM; Tavendale et al., 2005 with 91–107 g CT/kg DM; Williams et al., 2011 with 5–49 g CT/kg DM; Woodward et al., 2001 with 26 g CT/kg DM) and tannin extracts (Beauchemin et al., 2007 with 18 g CT/kg DM; Carulla et al., 2005 with 25 g/kg DM; Hess et al., 2006 with 25 g CT/kg DM; Pellikaan et al., 2011 with 100 g CT/kg DM; Tan et al., 2011 with 20–60 g CT/kg DM) have been extensively investigated for their ability to inhibit ruminal $CH_4$ production. Tannins reduce methane emissions by suppressing protozoa and other hydrogen-producing microbes thus interfering with methanogenesis (Patra, 2010; Tavendale et al., 2005).

Tea is one of the most popular beverages in the world (Khokhar and Magnusdottir, 2002); annual production totals approximately 4 million tons (Bordoloi, 2012). As part of the production of ready-made tea drinks packaged in bottles, packs and cans, beverage companies discard a large amount of tea grounds annually (Wang and Xu, 2013). Green tea extracts contain polyphenolic compounds that account for 30% of the dry weight of leaves (Mukhtar and Ahmad, 2000), and *in vivo* and *in vitro* studies (Mitsumoto et al., 2005; Wang and Xu, 2013; Zhong et al., 2009) have indicated that green tea polyphenols improve growth performance, meat quality and shelf life due to their antioxidant properties in cattle, sheep and goats. Flavanols, generally known as catechins, are the most abundant polyphenols in green tea leaves and account for nearly 80–90% of the total polyphenol content (Htay et al., 2008; Riemersma et al., 2001). The physiological effects of green tea depend on a variety of catechins, including epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG), and epigallocatechin gallate (EGCG), all of which are usually present in high concentrations in tea leaves (Spencer, 2003). The structural formation of EGCG (also known as condensed tannin) is believed to be responsible for the pronounced physiological activity of tea, including its antioxidant effects (Htay et al., 2008).

Sunphenon 30S-O is obtained from green tea (*Camellia sinensis*) leaves, and it is standardized for its catechin content. Catechin is the only polyphenol present in Sunphenon 30S-O, and the inclusion of such catechin-containing natural plant extracts in ruminant rations might influence $CH_4$ emissions, nutrient intake, digestibility and other rumen fermentation parameters. To the best of our knowledge, there is no information available on the effect of Sunphenon 30S-O on rumen fermentation, so this experiment was conducted to investigate the influence of Sunphenon 30S-O (containing a standardized level of catechin, 205 g/kg DM) on nutrient intake, digestibility, $CH_4$ emissions, VFA concentrations, $NH_3$-N concentrations, the protozoa population and rumen degradability.

## 2. Materials and methods

### 2.1. Sunphenon 30S-O

Sunphenon 30S-O, which is standardized for catechin content (205 g/kg DM), was obtained from the leaves of traceable green tea (*C. sinensis*) via extraction by water infusion and decaffeination using approved food-grade solvents. Catechin is the only polyphenol present in Sunphenon 30S-O, which contains water soluble fibres as filler and whose chemical composition and major catechin components are presented in Table 1. Samples of Sunphenon 30S-O were purchased from Taiyo Kagaku Co., Ltd., Japan; Sunphenon® extracts are food grade and approved by the Japanese Foundation for Health and Nutrition for specific medical uses. They are certified organic and possess an excellent tea taste and maintain good stability in beverages.