Effects of Feeding Wastes from *Brassica* Species on Growth of Goats and Pesticide/Insecticide Residues in Goat Meat

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ABSTRACT : The effects of feeding *Brassica* vegetable market wastes on intake, body weight changes and pesticide/insecticide residues in products of goats were evaluated in two experiments. In the first experiment (Exp. 1) 16 goats (Bach Thao, 9 to 10 kg, 3 months old, 9 males and 7 females) were fed four diets with leaves either from cabbage (*Brassica oleracea* var. *capitata),* cauliflower (*Brassica oleracea* var. *botrytis)* or Chinese cabbage (*Brassica campestris* subsp. *pekinensis)* with 30% of Para grass. The control group was fed 100% Para grass. All diets contained soybean waste as a supplement and the experiment lasted for 136 days. In the second experiment (Exp. 2) 24 goats (Bach Thao, 12 to 14 kg, all males) were assigned to three treatments in a completely randomised block design based on initial body weight. The goats were fed cabbage waste supplemented with 200 g or 100 g DM (dry matter) of concentrate. Para grass with 100 g DM concentrate supplementation was used as a control group. The experiment lasted for 90 days and at the end of the study, 12 goats were slaughtered for pesticide/insecticide analysis. Due to low DM content (5.3 and 3.7%, respectively) feed intakes of cabbage and Chinese cabbage groups were lower than those of other groups in the experiment. The highest feed intake and body weight gain was obtained when the goats were fed cauliflower (529 g DM/day and 87.5 g/day, respectively). In Exp. 2 total intake of cabbage and concentrate was similar (484 g and 453 g DM/day) whether the goats were fed 100 or 200 g concentrate/day but lower than that of Para grass and concentrate probably due to the low DM content of the cabbage (5.9%). Crude protein intake (79 g to 86 g/day) and body weight gain (70 g to 88 g/day) was not significantly different between treatments. Adding concentrate consequently resulted in higher DM intake than in Exp. 1 but did not result in any higher growth rate. Three of the pesticide/insecticide residues tested were found in cabbage, Alpha-Cypermethrin, Bassa-Fenobucarb and Dimethoate with levels of 0.175, 0.074 and 0.028 mg/kg fresh cabbage respectively. Weight of livers from goats fed cabbage was about 90 g higher than from goats fed Para grass but no pesticide/herbicide residues were found in meat or liver. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 2 : 197-202)***

Key Words : Goat, Cabbage, Cauliflower, Chinese Cabbage, Growth, Intake, Pesticide/Insecticide Residues

INTRODUCTION

Animal production in Vietnam is based mainly on smallholder farms. Use of local resources and crop by-products as livestock feeds is a necessary precondition for profitable production. Several by-products have potential value, especially for ruminants, due to their ability to digest fibre (Boucqué and Fiems, 1988). Utilisation of by-products is, however, limited due to the poor understanding of their nutritional and economic value as well as their proper use in ruminant rations (Schroeder, 1999). Among the less used by-products are the fruit and vegetable market wastes.

The cultivated area for vegetables in Vietnam is about 400,000 hectares, from which five million tonnes of gross output can be expected (General Statistical Office, 1999). Vegetables are normally not consumed completely but will partly be left in the field or destroyed during transport. Outer leaves (in the following referred to as waste) are often trimmed at the market. Discarded products are dumped, burnt or thrown into rivers as waste contributing to the problem of environmental pollution. According to a market survey by Ngu et al. (2001), the waste of leaves from cabbage species can reach 30% to 50% of total production. Especially cabbage waste is available in large quantities during the whole year. Leaves from *Brassica* species have been used for livestock feeding to a limited degree (Gustine and Jung, 1985) but utilisation of market wastes is neither efficient nor structured.

The nutritive value of *Brassica* species is influenced by the high water content (i.e., 8.6% dry matter (DM) in cabbage and 10.1% DM in cauliflower (Gupta et al., 1993)), which negatively affects intake. The DM, however, is rich in protein. For example cauliflower contains 20.8% crude protein (CP) (Gupta et al., 1993).

Other factors that affect the nutritive value of waste from *Brassica* species are anti-nutritional substances and secondary metabolites such as S-methyl-L-cysteine or glucosinolates (Duncan and Milne, 1993). Barry et al. (1981) demonstrated that the major factor limiting the feeding value of kale (*Brassica oleracea*) was the high content of these substances, which caused depressed voluntary intake. In addition, the wastes may contain pesticide or herbicide residues, which may have negative effects on rumen microorganisms. According to Duncan and Milne (1993) ruminants may be efficient in the detoxification of both anti-nutritional compounds and herbicides and pesticides, either by hepatic pathways or

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more probably as a result of rumen activity itself. Yousef et al. (1999) reported significantly increased weights of liver and spleen when sheep were orally fed test doses of Dimethoate 1.6 and 3.2 mg/kg BW (body weight) or Cypermethrin 6 to 12 mg/BW and day. Casteel et al. (1993) reported neurological dysfunction and sudden deaths of feedlot calves when the complete feed given contained 528 ug of Aldrin/g feed.

Forage *Brassica* species are widely exploited as ruminant feeds in temperate agricultural systems. However, few attempts have been made to exploit *Brassica* species in the form of vegetable waste as livestock feeds (Gupta et al., 1993).

The objective of the present experiments was to investigate the potential of using market wastes from Brassica species as feeds for goats especially in relation to feed intake, growth and eventual pesticide/insecticide residues in the goat meat.

MATERIAL AND METODS

Location and climate

The experiments were carried out at the experimental farm of Can Tho University, Can Tho City, Vietnam. In this area, the climate is monsoon tropical with a wet season between May and November and a dry season between December and April. Annual rainfall varies from 1.400 to 2.400 mm and mean air temperature is 26.6°C.

Experiment 1

Exp. 1 was carried out from April to September 2000. The feeds used in the experiment were three kinds of market waste, leaves from Chinese cabbage (*Brassica campestris*, subsp. *pekinensis*), cabbage (*Brassica oleracea* var. *capitata)* and cauliflower (*Brassica oleracea* var. *botrytis*) were collected at the Can Tho market in the morning and late afternoon. The leaves were fed directly when they were still green and fresh. Natural grass, mainly Para grass (*Brachiaria multica*) cut at an immature stage, was obtained from areas surrounding the university farm. Soybean waste, after being processed for soybean milk at a beverage factory in Can Tho, was collected daily and supplied fresh. A mineral lick including 60% mineral (85% $CaCO_3$, 15% trace elements), 20% wheat bran as carrier and 20% NaCl was available inside the pens.

Sixteen 3 month-old goats (3 groups with 2 males and 2 females and one group with 3 males and 1 female) with a BW of 9.2±0.16 kg at the start of the experiment, were selected from flocks of goats raised in confinement systems on farms in Can Tho province. The goats were of the Bach Thao breed, mature BW 63 kg, male; 42 kg, female. They were vaccinated against foot and mouth disease and treated against gastrointestinal parasites using Albendazole tablets before commencement of the experiments.

The goats were housed in individual pens on slatted floors and had access to clean water *ad libitum*. They were fed four times per day, at 07:00 h, 10:00 h, 13:00 h and 16:00 h. The feeds, Brassica species, Para grass and soybean waste or concentrate, were fed in separate containers.

The goats were randomly assigned to four dietary treatments based on BW and sex. The goats were adapted during one month by gradually exchanging Para grass for Brassica species. The treatments were 1) Chinese cabbage+ Para grass+soybean waste (ChC+PG+SB), 2) Cabbage+ Para grass+soybean waste (C+PG+SB), 3) Cauliflower+ Para grass+soybean waste (CF+PG+SB), 4) Para grass+ soybean waste (PG+SB).

Before the experiment started, the three cabbage species were analysed for DM and fed *ad libitum* to estimate the voluntary feed intake. The DM consumed from the cabbage species did not meet the nutritional requirements of the goats i.e. 36 g digestible CP and 5.52 MJ/kg ME for a 20 kg goat gaining 50 g/day (NRC, 1981) with an estimated DM intake of 3% of LW (Hai, 1994). Para grass was therefore included at 30% of DM offered. Addition of soybean waste supplied CP and energy to the diet. The study lasted for 136 d and 200 g/d of fresh soybean waste was fed during the first 65 d and 400 g/d for the last 71 d to meet the increasing requirements of the growing animals.

Feed samples were analysed weekly for DM to balance the amounts of Para grass and cabbage species. Amount of Para grass and cabbage species offered was increased weekly, based on the individual consumption the previous week, to supply 130% of voluntary intake for cabbage species and 150% for Para grass.

Feed samples were taken for analysis during the experimental periods. Feed intake was estimated daily by the difference between DM of amounts offered and refused. Samples of the refusals were collected individually daily and were pooled for 2 weeks and treatment group.

The changes in BW gain were recorded by weighing the goats monthly, always in the morning before feeding.

Experiment 2

Exp. 2 was carried out from February to May 2002. The feeds used were cabbage waste (*Brassica oleracea* var. *capitata*), Para grass of the same quality as in Exp. 1 and a concentrate consisting of rice bran (50%), broken rice (40%) and molasses (10%). In order to make it possible to mix the ingredients, 500 g water was added to 1.6 kg concentrate to get the feed that was presented to the animals. Salt was available in the pens.

Twentyfour 4-month old male goats with an initial BW of 13.1±0.81 kg of the same breed and origin as in Exp.1 were selected. The vaccinations, housing and feeding

Table 1. Chemical composition of the diet components*

Item	Exp.1					Exp. 2		
	ChC	C	CF	PG	SB	C	PG	Con
n	8	8	8	8	4	3	3	3
DM (g/kg)	37±2	53±5	102±5	158±7	221±2	59±6	159±1	705±2
g/kg DM								
Ash	172±4	137±2	141±13	119±8	10±5	130±2	130±10	47±3
CP	295±3	233±9	297±3	140±2	378±3	218±7	118±2	92±8
NDF	253±2	279±3	276±2	678±2	175±2	295±3	653±2	279±1
ADF	223±1	236±2	210±1	357±1	129±1	210±3	332±2	104±1

* Means and standard deviation, n=number of samples; ChC: Chinese cabbage *Brassica oleracea* var. *capitata*, C: cabbage *Brassica oleracea* var. *botryti*; CF: cauliflower *Brassica campestris* subsp. *Pekinensis*; PG: para grass; SB: soybean waste; Con: concentrate.

routines were the same as in Exp. 1. Cabbage waste, Para grass and concentrate were fed in separate containers.

The goats were assigned to a completely randomised block design based on initial weight and were kept one month for adaptation to the new feeds. The treatments were 1) Cabbage waste+200 g DM concentrate (C+200 Con), 2) Para grass+100 g DM concentrate (PG+100 Con) and 3) Cabbage waste+100 g DM concentrate (C+100 Con). The study lasted for 90 days.

Amount of Para grass and cabbage waste offered was increased weekly, based on the individual consumption the previous week, to supply 130% of voluntary intake for both cabbage and Para grass.

Samples of fed and refusals were collected as in Exp. 1. The changes in BW gain were recorded by weighing the goats every second week, always in the morning before feeding. At the end of the experiment 12 goats were slaughtered and liver and muscle samples from the hind legs (biceps femoris) were taken for analyse of pesticides/insecticides.

Chemical analyses

DM and ash were determined according to the procedures of AOAC (1990). Nitrogen (N) determination was made by the Macro Kjeldahl method and CP calculated as N×6.25. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analysed according to the method described by Van Soest and Robertson (1985).

Pesticide/insecticide concentration was determined using a gas chromatograph (Shimadzu, model 14B) following the method described in AOAC (2000). Fifteen g cabbage sample was chopped, mixed and homogenized with 30 ml acetone in a centrifuge tube for 30 seconds. Dichloromethan and petroleum ether, 30 ml of each, was added and homogenized another 30 seconds. The tube was then centrifuged for 2 minutes at 4,000 rpm and the organic extract was decanted for further clean-up procedure using Gel Permeation Chromatography. The liver and muscle samples were cut in cubes of approximately 1 cm size and 25 g was placed in a glass funnel with 70 mm diameter placed on top of a conical flask. The sample was heated at 65°C for 6 h. The rendered fat was dissolved in light petroleum so that the solution contained less than 200 mg fat/ml and was further cleaned up as mentioned above (AOAC, 2000). Being known as commonly used pesticide/insecticides, the following six compounds were analysed: Alpha-Cypermethrin, Bassa-Fenobucarb, Dimethoate, Aldrin, Endosulphan and Diazinon.

Statistical analysis

Data were analysed by variance analysis using the General Linear Model (GLM) of Minitab Software 12.21 (1998). When the F-test was significantly different ($p<0.05$), Tukey's test for pair wise comparisons was used. The following statistical model was used:

$$Y_i = \mu + A_i + E_i \qquad \text{(Exp. 1)}$$

where, Y_i = dependent variable; μ = overall mean; A_i = effect of diet; E_i = random error.

In Exp. 2 the effect of block was included. The effect of sex was tested in Exp. 1 but not included in the model, as there were no significant differences due to sex.

RESULTS

The DM was low in all *Brassica* species and especially low (3.7%) in Chinese cabbage (Table 1) and the variation in DM content during the experiments was also low. High levels of CP were observed in all three species of *Brassica*. The NDF and ADF of cabbage species were low.

In Exp. 1 the animals fed the cauliflower diet had higher ($p<0.05$) DM intake than those fed the Para grass diet. The Chinese cabbage diet had the lowest intake (Table 2). Intake of CP was highest ($p<0.05$) for the cauliflower diet. NDF and ADF consumption was highest for goats fed the Para grass diet followed by cauliflower, cabbage and Chinese cabbage diets.

In Exp. 2 the different levels of concentrate that were supplemented to the basic feeds clearly were influencing feed intake (Table 2). Goats that were supplemented with 200 g DM concentrate/day were consuming less cabbage

Table 2. Feed intake of the experimental diets*

	Exp.1, diets					Exp. 2, diets			
	ChC+ PG+ SB	C+ PG+ SB	CF+ PG+ SB	- PG+ SB	SE	C+ 200 Con	PG+ 100 Con	C+ 100 Con	SE
Feed intake (g DM/day)									
Chinese cabbage	162	-	-	-	-	-	-	-	-
Cabbage	-	197	-	-	-	284	-	353	-
Cauliflower	-	-	353	-	-	-	-	-	-
Paragrass	54	63	109	355	-	-	570	-	-
Soybean waste	67	67	67	67	-	-	-	-	-
Concentrate	-	-	-	-	-	200	100	100	-
Total	283^{d}	327^{c}	529^{a}	422^{b}	25.8	484^{b}	670^{a}	453^{b}	19.7
Nutrient intake (g/day)									
OM	249^{d}	294^{c}	467^{a}	380^{b}	22.5	438^{b}	586^{a}	402^{b}	17.4
CP	81^{b}	81^{b}	146^{a}	80^{b}	7.2	82	79	86	3.5
NDF	88^{d}	108^{c}	181^{b}	249^{a}	16.5	139^{b}	394^{a}	132^{b}	10.2
ADF	62^{d}	80^{c}	122^{b}	145^{a}	9.4	79^{b}	295^{a}	83^{b}	5.6
DM intake (% of BW)	2.1^{b}	2.3^{b}	3.5^{a}	3.0^{a}	0.1	2.9^{b}	4.1^{a}	2.8^{b}	0.2
DM intake (g/kg $W^{0.75}$)	40^{c}	45^{bc}	69^{a}	59^{b}	3.1	59^{b}	82^{a}	56^{b}	3.2

* Least squares means and SE, ^{a,b,c,d} Means within rows and experiments with different superscripts are significantly different ($p<0.05$).
ChC: Chinese cabbage *Brassica oleracea* var. *capitata;* C: cabbage *Brassica oleracea* var. *botrytis.*
CF: cauliflower *Brassica campestris* subsp. *Pekinensis;* PG: para grass; SB: soybean waste; Con: concentrate.

Table 3. Effect of diets on daily live weight gain (LS-means and SE)

	Exp.1, diets					Exp. 2, diets			
	ChC+ PG+ SB	C+ PG+ SB	CF+ PG+ SB	PG+ SB	SE	C+ 200 Con	PG+ 100 Con	C+ 100 Con	SE
Initial weight (kg)	9.5	9.2	9.3	9.6	0.2	13.3	12.6	13.3	0.81
Final weight (kg)	18.0^{b}	19.1^{b}	21.2^{a}	18.3^{b}	0.4	20.2	20.6	19.6	1.06
BWG (g/day)	62.8^{c}	73.4^{b}	87.5^{a}	64.0^{c}	2.7	76	88	70	5.6
FCR (kg DM/kg BWG)	4.5^{c}	4.5^{c}	6.0^{b}	6.7^{a}	0.3	6.5	7.6	6.6	0.4

^{a,b,c} Means within rows and experiment with different superscripts are significantly different ($p<0.05$).
BWG: body weight gain; FCR: feed conversion ratio; CHc: Chinese cabbage *Brassica oleracea* var. *capitata;* C: cabbage *Brassica oleracea* var. *botryti:*
CF: cauliflower *Brassica campestris* subsp. *Pekinensis:* PG: para grass: SB: soybean waste; Con: concentrate.

Table 4. Pesticide/insecticide content in feeds and animal products, Exp. 2

Samples	Alpha-fenobucarb	Bassa-cypermethrin	Dime-thoate	Aldrin	Endosul-phan	Diazinon
Cabbage (mg/kg fresh)	0.175	0.074	0.028	ND	ND	ND
Para grass	ND	ND	ND	-	-	-
Concentrate	ND	ND	ND	-	-	-
Liver (C+200 Con)	ND	ND	ND	-	-	-
Muscle (C+200 Con)	ND	ND	ND	-	-	-
Liver (C+100 Con)	ND	ND	ND	-	-	-
Muscle (C+100 Con)	ND	ND	ND	-	-	-

ND: not detected; - not analysed.

than those supplemented with 100 g. The total amount of DM that was consumed in these two rations was, however, similar (484 and 453 g/day), leading to a non-significant difference in DM intake expressed as percentage of BW (2.9 and 2.8%). In spite of the difference in level of concentrate supplementation and CP components, the amount of CP consumed by the goats in three diets was nearly similar (82, 79 and 86 g/day, respectively).

Goats that were fed the cauliflower diet in Exp. 1 had the highest ($p<0.05$) growth rate, 87.5 g/day, compared to the other diets and the goats that were fed the Chinese cabbage diet the lowest, 62.8 g/day. In Exp. 2 the differences in live weight gain between the treatments were not statistically significant although goats fed Para grass had slightly higher growth rates (88 vs. 76 and 70 g/day).

Three of the six kinds of possible pesticide/insecticide residues that were tested in Exp. 2 were found in cabbage. Alpha-Cypermethrin, Bassa-Fenobucarb and Dimethoate (Table 4) but no residues were detected in grass or concentrate. None of the residues were detected in goat meat or liver indicating no harmful effects for humans consuming meat from goats fed cabbage waste. The spleen

Table 5. Weight of liver and spleen of the goats, Exp. 2

	Diets Exp. 2			
	C+200 Con	PG+100 Con	C+100 Con	SE
Liver (g)	353[a]	256[b]	348[a]	17.9
Spleen (g)	27	27	30	1.4

[a, b] Means within rows with different superscripts are significantly different ($p<0.01$).
C: Cabbage *Brassica oleracea* var. *botrytis*.
PG: para grass; Con: concentrate.

weight was normal and similar in three treatments. The weight of the liver was, however, significantly ($p<0.01$) higher for the diets containing cabbage.

DISCUSSION

The present results concerning the chemical composition of cauliflower were in agreement with the results of Francis (1980), who reported that the DM and CP content of cauliflower was 7.7% and 29%, respectively. The NDF content of cauliflower was slightly higher in this study than obtained by Gasa et al. (1989). Concerning cabbage the present results were slightly lower than those from Gupta et al. (1993), who reported that DM and CP content of cabbage was 8.6% and 28%, respectively. Low NDF and ADF percentages were also observed in cabbage. The chemical compositions of the feeds used in the two different experiments in this paper were similar. The differences compared to results reported in the literature may be due to season, development stage, variety or production system.

Among the cabbage species studied, the adaptation of the goats to the feeding of cauliflower and cabbage was faster than to Chinese cabbage. Soybean waste was readily accepted, as was the concentrate when mixed with molasses. The difference in intake of the *Brassica* species can be due to the different DM contents, which have been suggested to limit DM intake (Lambert et al., 1987). However, lambs fed *Brassica* forage containing 91.2% water consumed nearly enough DM to meet recommendations for growth (Cassida et al., 1994). In Exp. 2 concentrate was added to the diets to increase the DM content. This resulted in lower cabbage intake at higher levels of concentrate supplementation. Subsequently there was a substitution effect of the concentrate. In this case an addition of 100 g DM concentrate decreased the intake of cabbage with 69 g DM.

Higher intake of CP resulted in higher growth rates in Exp. 1. Evidently there was a genetic capacity for growth rate around 85 g/day, which could be expected when the CP intake was sufficiently high. Goats fed the cauliflower diet over consumed CP in relation to the requirements (26 g digestible CP for maintenance and 20 g digestible CP for gaining 100 g/day for a 20 kg goat according to NRC (1981). The surplus of CP would have been excreted in the urine, which was not analysed in Exp. 1. Different diets from the cabbage species offered gave acceptable daily gains compared to those from traditional or conventional feeds. The growth rate of 5 to 6 month old Bach Thao goats fed *Sesbania grandiflora* was 100±34 g, as reported by Thuy and Do (1996). Similar results were reported by Tien and Nhan (1998), who found that goats gained 78 g/day when given *Leucaena leucocephala*. Live weight gain of the goats fed Chinese cabbage and Para grass were lower than suggested by Binh et al. (1995) for Bach Thao goats of 6 to 9 months of age (87 to 111 g/day).

Adding concentrate to the cabbage in Exp. 2 increased DM intake but the levels of CP intake were similar to the cabbage diet in Exp. 1 and the live weight gains were between 70 and 76 g/day for the cabbage diets in the two experiments. Since the content of energy in the diets is not known it is not possible to compare energy intake, the diets may be similar also in that respect.

It is commonly known that *Brassica* species may contain pesticide/insecticide residues and different amounts of compounds called glucosinolates of which breakdown products are responsible for various toxic symptoms (Duncan and Milne, 1992). It was reported by Chi (1997), that pesticide levels present on cabbage leaves were relatively high. In this study three of the six kinds of compounds considered commonly used were found at low levels in the cabbage leaves. None of the residues were, however, carried over to goat meat or liver. Few comparative figures in the literature in this field made it difficult to determine the tolerance of goats to these kinds of toxins. Which levels will have an effect on animal performance, and ultimately on product quality and human health, is open to debate.

The glucosinolates were not analysed in these experiments but the high liver weights from goats fed the cabbage diets in Exp. 2 indicate increased liver activity implying break down of toxic substances.

CONCLUSIONS

The results from the studies showed that the best performance in intake and live weight gain was obtained when the goats were fed cauliflower leaves and soybean waste. Cabbage and Chinese cabbage can be potentially useful feeds, especially cabbage since it is available in large amounts all the year around. Adding concentrate resulted in higher DM intake but did not result in any higher growth rate.

There may have been some effects of pesticides/herbicides or glucosinolates resulting in increased liver activity and manifested as higher liver weights. However, the pesticides/herbicides were not detectable in muscle samples and liver.

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