Utilization of Maize Animal Feeds in Northern Upland Region of Vietnam

การใช้ประโยชน์ข้าวโพดด้านอาหารสัตว์ในพื้นที่สูงเขตภาคเหนือของประเทศเวียดนาม

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บทคัดย่อ: ในประเทศเวียดนามข้าวโพด (*Zea Mays* Linnaeus) จัดเป็นพืชอาหารที่มีความสำคัญเป็นอันดับสองรองจากข้าว ซึ่งมีการผลิตในหกภูมิภาคเกษตรกรรมหลักที่สำคัญอันได้แก่ ภูมิภาคพื้นที่สูงทางตอนเหนือของประเทศ สามเหลี่ยมปากแม่น้ำแดง ภูมิภาคชายฝั่งตอนกลางภูมิภาคที่ราบสูงตอนกลางภูมิภาคตะวันออกเฉียงใต้และสามเหลี่ยมปากแม่น้ำโขง โดยที่พื้นที่สูงเขตภาคเหนือของประเทศเป็นแหล่งผลิตข้าวโพดชั้นนำมีผลผลิตสูงถึง 1,844,000 ตัน ในขณะที่ผลผลิตทั่วทั้งประเทศในปี 2012 มีอยู่ที่ 4,973,600 ตัน จากผลผลิตข้าวโพดดังกล่าวไม่เพียงส่งผลต่อการบริโภคและการดำรงชีวิตของประชากรหากแต่ยังใช้เป็นวัตถุดิบอาหารสัตว์ในประเทศเวียดนามด้วย โดยเมื่อไม่นานมานี้มีการศึกษาจำนวนมากที่มุ่งเน้นการแสวงหา และการใช้ประโยชน์จากวัตถุดิบที่มีอยู่ในท้องถิ่น เช่น ข้าวโพด เพื่อใช้ในอุตสาหกรรมการเลี้ยงสัตว์มากขึ้นโดยเฉพาะอย่างยิ่งเพื่อเป็นวัตถุดิบอาหารสัตว์ โดยจากผลการศึกษาพบว่ามีความเป็นไปได้ที่จะนำมาใช้เพื่อเป็นวัตถุดิบอาหารสัตว์ เนื่องจากสามารถหาได้ง่ายในท้องถิ่นและมีราคาย่อมเยา โดยบทความนี้จะรวบรวมงานวิจัยและการศึกษาต่าง ๆ ที่ครอบคลุมเกี่ยวกับผลผลิตข้าวโพดในพื้นที่สูงเขตภาคเหนือของประเทศเวียดนาม ต่อการนำมาใช้ประโยชน์ในด้านอาหารสัตว์

คำสำคัญ: ข้าวโพด การใช้ประโยชน์ อาหารสัตว์ พื้นที่สูงเขตภาคเหนือของประเทศเวียดนาม

Abstract: In Vietnam, maize (*Zea mays*Linnaeus) is the second most important food crop, following to rice. It is produced in six major agro-ecological regions, including the northern upland region, Red river delta, central coast region, central highland region, south-eastern region, and the Mekong river delta.The Northern upland region ranks the top corn producers over the country, reaching 1,844,000 tons among 4,973,600 tons nationwide production in 2012. Maize not only contributes to local human subsistence, but also used as feedstuff in Vietnam livestock industry. Recently, many studies have focussed on investigating utilization of locally available ingredients, in general and maize in particular in animal feed. It has been concluded that these feedstuffs are very feasible due to their availability and cheapness.The review presents comprehensive on maize production in Northern upland region of Vietnam and its use in animal feeds.

Keywords: Maize (*Zea mays* Linnaeus), utilization, animal feed, northern upland region of Vietnam

Introduction

Vietnam, a tropical country in Southeast Asia, has a total land area of 331,700 km^2 and a long coastline of 3,260 km, with over 70% of areas less than 500 m above sea level (masl), and three quarters mountains, hills covered. The Northern Upland region of Vietnam, among poorest region over the country, is characterized by hilly location, poor infrastructure, low population density, high share of ethnic minorities, less urbanized and largely dependent on agriculture activities. Regarding agriculture products, maize is the second most important food crop, next to rice in the region (Gerpacio, 2001; Ha *et al.,* 2004). Maize is mostly produced in the region, reaching 1,844,000 tons (national production, 4,973,600 tons), covering an area of 502,000 ha (GSO, 2012). This crop product plays an important role in farm household economy as food and in animal feed (Dao *et al.,* 2002; Ha *et al.,* 2004).

With regard to farmers' subsistence, maize used to be main food in human diets, substituting rice at former stage (rice deficiency), especially for ethnic minorities in Northern upland region (Ha *et al.,* 2004). As Vietnam becomes one of the world top rice exporters, the situationis now considered as a temporary strategy that households turn to only in times of emergency (Bonnin and Turner, 2012). Maize, with latter regard, is cultivated rather than subsistence, many of that (62.2% total products) are sold to market after harvesting and used as ingredient for animal feed in low land (Tuan, 2010). Moreover, among 37.2% total un-sold products the use for feed industry dominates (28.5%), only 9.3% is of human consumption and seed reservation (Ha *et al.,* 2004). Maize grain is well-known for being important and basis source of energy in animal feed (Law, 1986; Kim *et al.,* 2009; Tuan, 2010). As livestock sector is projected to increase, the demand for maize and other local ingredients will follow that trend, especially for the rise of aquaculture (fisheries sector) which is recently grown dramatically and significantly contributes to worldwide food security and famers' income generation in the region (FAO, 2005; Steinbronn, 2009).The aim of this study is to review, i) researches on corn meal composition and ii) use of corn meal in Northern upland region of Vietnam in livestock feeds.

Study area and chemical analysis

The sample of corn meal was collected from Thai Nguyen province, Northeast of Vietnam (Figure 1). The location is in the monsoon tropical climate zone with two distinct seasons, rainy season (May to October; annual average temperature of 27-29°C) and dry (November to April; annual average temperature of 16-20°C) (Anh *et al.,* 2011).

Maize meal of about 200-300g was purchased at Thai Nguyen Central market, Thai Nguyen province, Vietnam and analyzed for chemical composition, dry matter (DM), crude protein (CP), crude lipid (CL), ash, crude fiber and gross energy, at Central Laboratory, Faculty of Animal Science, Vietnam National University of Agriculture, Vietnam. These data create basic knowledge for further experiments.

These chemical analyses base on standard method of the Association of Official Analytical Chemists (AOAC, 1995)was determined by using 5g sample and stored in oven at 105°C for 24h for moisture. CP (N x 6.25) by measuring nitrogen by the Kjeldahl method, CL by ether extraction using the Soxhlet method, ash by heating at 550°C for 24 h in a muffle furnace, GE by using an automatic Parr 1281 oxygen bomb Calorimeter. The crude fiber was determined by the Weende method (James, 1995).

Maize cultivation in northern upland region of Vietnam: Areas and production

This region has 14 provinces, including Ha Giang, Cao Bang, Lao Cai, Bac Kan, Lang Son, Tuyen Quang, Yen Bai, Thai Nguyen, Phu Tho, Bac Giang, Lai Chau, Dien Bien, Son La, and Hoa Binh

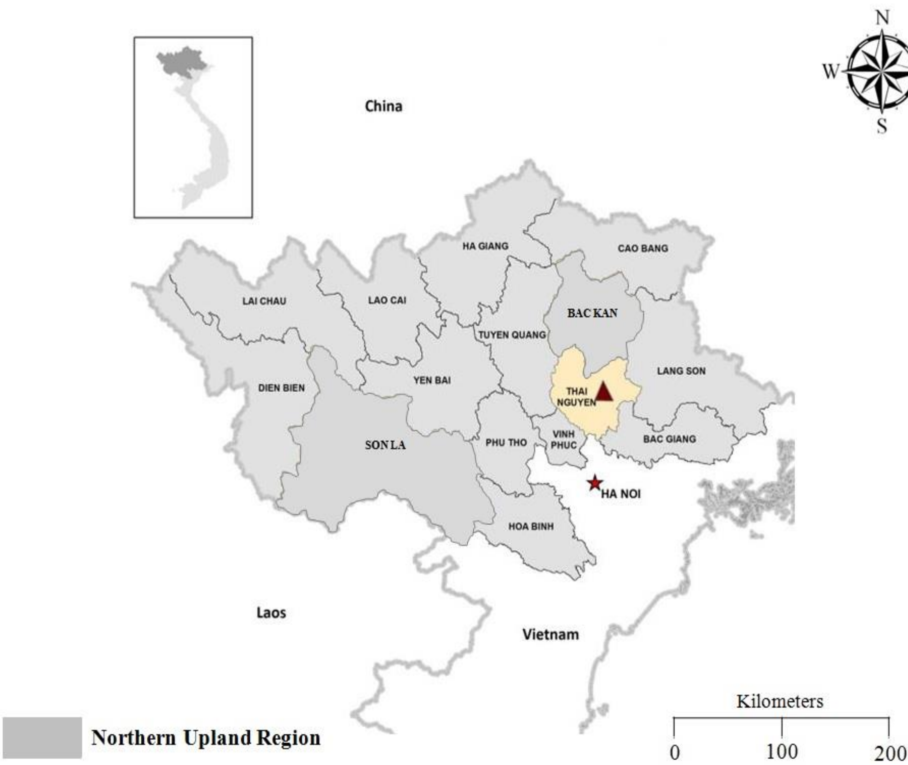

Figure 1 Northern upland region and Thai Nguyen province, Vietnam

Source: Map of Northern upland region by ICEM (2015) (modified)

(Figure 1), where most of Vietnam's maize production are provided. The region consists of two sub-regions, the northwest region is highland and mountainous (700 to above 2,000 masl), the northeast region includes either upland or lowland areas (400 to 500 masl) (Thao, 1997).

Maize is mainly cultivated in rain-fed conditions and in areas closely open to irrigation systems. In the Northern upland, annual single maize crop is commonly found in, whereas the double are most available in the upland of northeast (Ha *et al*., 2004; Keil *et al*., 2008). Having largest area of maize cultivation among country (region/nation: 502,000/1,156,000 ha), the region produces dominantly corn grain compared to other regions and become largest corn producers (1,844,000 tons). Son La, Ha Giang, and Hoa Binh are among the most three corn contributors, reaching 667,300, 168,700, and 143,800 tons, respectively. Although the average maize yield in region is slightly lower than that of national level (4.30 tons/ha), Lang Son and Phu Tho province however surpass that level (4.76 and 4.55 tons/ha, respectively) (Table 1).

Thai Nguyen province is a midland location, connecting upland and low land province in northern of Vietnam. Maize, the third most important field crop, ranking behind rice, tea, is cultivated in an area of 17,900 ha, with production of 76,400 tons in 2012 (ranking eighth in Northern upland region). The yield of corn is reported at relatively high value (4.27 tons/ha), marginally reaches national level (Table 1). The maize yield depends on many factors, in which fertilizers, maize cultivars, plant protection solutions, and mechanization are mainly considered. It was reported that these factors contribute to 40, 30, 20, and 10%, respectively to maize yield in China, however the first is estimated to surpass 40% in Vietnam (Feng, 2012; Bo, 2013). In addition, weed

Table 1 Areas (1,000 ha) and production (1,000 tons) of maize Northern upland region of Vietnam

Provinces	Areas (*1,000 ha*)	Production (*1,000 tons*)	Yield (*tons/ha*)
Country	1156.60	4973.60	4.30
Region	*502.00*	*1,844.0*	*3.67*
Ha Giang	52.50	168.7	3.21
Cao Bang	39.30	127.0	3.23
Bac Can	16.50	61.8	3.75
Tuyen Quang	14.10	60.4	4.28
Lao Cai	33.70	115.6	3.43
Yen Bai	24.70	75.5	3.06
Thai Nguyen	17.90	76.4	4.27
Lang Son	21.80	103.8	4.76
Bac Giang	8.60	33.6	3.91
Phu Tho	17.40	79.1	4.55
Dien Bien	29.20	71.6	2.45
Lai Chau	21.40	59.4	2.78
Son La	168.70	667.3	3.96
Hoa Binh	36.20	143.8	3.97

management regimes also contributes to variation on maize yield. Pornchai (1998) reported that hand weeding 1 time at 15 days after planting could increase yield of corn 29.0% when compared to non weeding plot, that at 30 days and 45 days gave higher yield of 63.0% and 75.8%, respectively. The application of pre-emergence herbicide propisochlor (2-chloro-N-(isopropoxy methyl-N-(2-ethyl-6-methylpheny1)-acetame) 172.8 g ai/rai provided 37.1% higher yield of corn. The application of propisochlor and following with hand weeding at 45 days after planting was able to increase yield 57.2%. The application of propisochlor as preemergence herbicide and following with non-selective postemergence herbicide paraquat (1, 11-dimethyl-4,4/-bipyridinium ion) 1 10.4 g ai/rai at 45 days after planting could increase yield up to 45.9%.

Chemical, physiological and other properties

Maize grain meal originated from various locations in Northern upland region is studied chemical composition. It is reported that this product is similar in quality to that from other countries and this is not only a source of carbohydrate but also a good supplemental protein source (Khoi *et al*., 1987; Tuan, 2010).

Data on chemical composition of corn meal sampled in Thai Nguyen is present in table 2. In details, the dry matter, crude protein, crude lipid, crude fiber, ash (%) and gross energy (Mj/kg) are 89.58, 9.45, 4.29, 1.94, 1.91% and 20.10 Mj/kg, respectively (Hung *et al*., 2015a,b).

It is apparent that dry matter, crude protein and gross energy of corn meal are in good similarity, while there are slightly differences on crude lipid, crude fiber and ash content, among researches.

Glencross *et al*. (2007) and Amin (2011) stated that environment factors such as temperature, soil, water, site and season; as well as species of origin, genotype or cultivar can induce substantial variation in nutrient parameters. These can be easily seen with maize grown in Northern upland region of Vietnam. In details, the region consists of two sub-regions, northern-west and northern-east which largely differentiate by height (masl), rainfall, and average temperature (700-2000 masl; 2000 mm; 23 ^{o}C and 400-500 masl; 1800mm; 23.4 ^{o}C, respectively). Moreover, types of soil significantly vary between agro-ecologies in the region, while northern upland soils includes humicgray soil (*humicacrisols*), red-yellow humic soil (*humicferrasols*), gray soil (*ferralicacrisols*), alluvium soil (*eutricfluvisols*) and new alluvial soil (*dystricfluvisols*) along rivers and creeks, and brown-red soil on limestone (*luriccalcisols*), alluvium soil (*eutricfluvisols*) is commonly found in the northern lowland agro-ecological zone (Ha *et al.,* 2004). On the other hand, each type of soil will benefit specific maize type and requires certain fertilizers. In Vietnam, there are currently various maize cultivars, including long-duration growth and mediate-early mediate growth group, each is characterized by its own chemical compositions. This effect was also found in Lupin species of *Lupinusangustifolius* (Glencross *et al.,* 2003). Fertilizer is one of main factor driven to yield, growth (Amnuaysilpa and Surasak, 1990; Suksri, 1992; Saowakon and Sasithorn, 2011) as well as a part to maize composition, it was reported that fertilizer input (nitrogen) had significant effect on seed protein content of maize (Amin, 2011; Bo, 2013; Safari *et al.,* 2014). In the region, farmers often apply inorganic fertilizers (NPK, urea) with a quantity of 190kg/ha, and the ratio of N:P:K is 1:0.51:0.39 (Bo, 2013).

In addition to the difference on chemical composition of corn meal, its process technology, any physical process (i.e. heat, grinding, and extraction) will affect the value of an ingredient (Glencross *et al*., 2007).

The high ash and fiber content observed on table 2, could have negative on apparent digestibility of dry matter and ash on fish (Masagounder *et al.,* 2009)

Compared to other cereal grains, corn is lower in protein and slightly higher in energy. The protein in corn is approximately 55 to 60% escape or bypass protein (protein that is not fermented or degraded by the ruminal microorganisms, but is digested and absorbed by the animal in the small intestine). The remaining 40 to 45% of the protein in corn is rumen-degradable protein (Ruminal microorganisms require rumen-degradable protein for use in growth and protein synthesis). Corn contains approximately 70 % starch on a dry-matter basis (NRC,1993). Like all among cereal, corn is low in calcium and relatively high in phosphorus. Diets containing high levels of corn should include a supplemental calcium source, such as limestone, to prevent urinary calculi. The recommended calcium to phosphorus ratio in animal diets is a minimum of 2-to-1 (NRC, 1993).

In term of amino acid (Table 3), maize is limited as a feed ingredient owing to the deficiency of some essential amino acids compared with other grains and oilseeds, and in fish diets lacking protein ingredients produced from fish or animal/poultry byproducts, lysine is nearly always the first limiting amino acid (Gatlin *et al.,* 2007). However, Tuan (2010) found that some ofthe normally most deficient amino acids such as lysine, cystine and methionine were richer in Son La maize than those reported by Khoi *et al.* (1987) for some maize cultivars in Northern of Vietnam. The difference on amino acid could be linked to some mutant maize in compared with normal cultivars. For example, a mutant maize, "opaque-2" produces kernels containing the same amount of crude protein but with nearly twice the amount of lysine and higher tryptophan levels relative to common maize types, and QPM cultivar with superior biological protein value that is about

Table 2 Chemical composition (%), gross energy (Mj/kg) of maize meal derived from various sources

	Northern Upland region						Mekong Delta[7]	NRC[8]
	Thai Nguyen[1]	*Son La*[2]	*Son La*[3]	*Northern region*[4]	*Son La*[5]	*Northern region*[6]		
Dry matter	89.58	88.2	-	87.91	86.9	-	-	88.0
Crude protein	9.45	9.1	10.9	10.32	11.8	10.74	8.7	8.5
Crude lipid	4.29	4.8	6.5	3.71	-	-	2.7	3.6
Crude fiber	1.94	-	-	3.16	-	-	-	-
NDF[9]	-	-	13.6	-	-	-	15.3	-
ADF[10]	-	-	3.7	-	-	-	-	-
ADL[11]	-	-	0.3	-	-	-	-	-
Ash	1.91	7.9	1.4	2.16	-	-	4.8	1.3
Gross energy	20.10	-	20.9	17.85	21.2	-	15.9	-

Source: [1]Hung *et al*. (2015a,b), [2]Thu (2012), [3]Tuan (2010), [4]Son *et al*. (2009) value in average, [5]Steinbronn (2009) [6]Khoi *et al*. (1987), [7]Da *et al*. (2012), [8]NRC (1993), [9]NDF neutral detergent fibre, [10]ADF acid detergent fibre, [11]ADL acid detergent lignin

Table 3 Amino acid profiles (g/100g protein) of maize meal (MM) reported by some authors

	MM[1]	MM[2]			MM[3]						
		Normal	*Opaque-2*	*QPM*[a]	*Cuc*	*Nep hoa*	*Nep Vang*	*Gie*	*NN2*	*2A*	*Opaque-2*
Total protein	10.9	9.1	8.9	9.8	11.2	10.5	8.4	12.9	12.1	9.7	10.4
Arginine	4.95	5.60	6.62	6.73	3.0	2.80	3.80	3.50	2.10	2.60	1.10
Histidine	2.11	3.07	3.84	3.77	2.50	1.50	2.00	2.80	1.50	1.70	3.00
Isoleucine	3.21	3.76	3.37	3.26	-	-	-	-	-	-	-
Leucine	8.81	12.52	8.98	9.28	17.05	16.31	15.01	16.00	17.00	16.10	15.82
Lysine	3.85	3.40	4.49	4.08	1.70	1.90	2.50	2.00	1.90	1.70	2.80
Methionine	1.83	1.73	1.57	1.73	1.90	2.35	2.00	2.00	1.50	2.21	2.75
Phenylalanine	4.04	5.16	4.38	4.18	3.90	5.11	4.08	4.67	4.00	5.00	5.12
Threonine	3.59	3.84	3.59	3.67	3.50	3.00	3.50	3.91	2.90	3.70	3.90
Tryptophan	0.83	0.59	0.73	0.75	0.57	0.64	0.51	0.41	0.52	0.60	0.47
Valine	4.40	5.05	5.39	5.30	5.30	4.50	4.80	5.00	4.20	4.20	4.50

[1]Tuan (2010), [2]Nuss and Tanumihardjo (2010), [3]Khoi *et al*. (1987), [a]Quality protein maize

90% versus 40% in common maize (Nuss and Tanumihardjo, 2010).

Typical yellow maize contains many important vitamins with the notable exception of vitamin B-12. Vitamin A, as provitamin A carotenoids, and vitamin E, as tocopherols, are the predominant fat-soluble vitamins found in maize kernels (Table 4). Both carotenoids and tocopherols play important roles as antioxidants among other functions (Kurilich and Juvik, 1999; Nuss and Tanumihardjo, 2010).

About 80% of the kernel's minerals is contained in germ and less than 1% of that is distributed in the endosperm (Table 5). Phosphorus, potassium, and magnesium are the most prevalent minerals found in maize, providing nearly 85% of kernel mineral content (Miller, 1958). The 4th most abundant element is sulfur, mostly present in an organic form as a constituent of methionine and cystine (Watson, 1987). Zinc levels average 20 µg/g, 30% of which resides in the kernel endosperm. Total calcium and iron levels are negligible and the concentrated germ phytate levels retard the bioavailability of these minerals. Significant genotypic variation has been observed for iron and zinc concentrations in maize inbred grown at various latitudes. Zinc concentrations ranged from 12 to 96 µg/g and iron14 to 159 µg/g, with higher mineral levels associated with higher growing latitudes. Other trace minerals include manganese, copper, selenium, and iodine (Nuss and Tanumihardjo, 2010).

Up to date, little is known about vitamin and minerals contained in maize in upland Northern of Vietnam. Inclusion of maize in animal and aquatic

Table 4 Average percent (ranges) of total major carotenoid and tocopherol fractions in 10 corn inbred

Carotenoids		Vitamin E	
Total carotenoids (µg/g)	31.5 (0.09 to 72)	Total tocopherols (µg/g)	548.3 (282 to 1016)
	% total		% total
Carotenes	27 (8.6 to 67.3)	α-tocopherol	24 (2.5 to 42.3)
Cryptoxanthin	10 (4.7 to 22.1)	α-tocotrienol	13 (4.3 to 22.4)
Lutein	41 (10.9 to 64.2)	γ-tocopherol	47 (25.8 to 82.6)
Zeaxanthin	22 (5.8 to 68.3)	γ-tocotrienol	16 (5.1 to 28.4)

Source: adapted from Weber (1987).

Table 5 Proximate chemical analysis of the main parts of maize kernels (%)

Chemical component	Pericarp	Endosperm	Germ
Protein	3.7	8	18.4
Ether extract	1	0.8	33.2
Crude fiber	86.7	2.7	8.8
Ash	0.8	0.3	10.5
Starch	7.3	87.6	8.3
Sugar	0.34	0.62	10.8

Source: Watson (1987) and (FAO 1992), cited by Nuss and Tanumihardjo (2010)

diets aims to provide cheap carbohydrate component.

Bioactive compounds in and nutritional limitations of maize

Corn products contain xanthophylls, a group of yellow carotenoid pigments, and pigment levels are concentrated in corn gluten meal compared with the xanthophyll content of ground corn. Rainbow trout fed diets containing corn gluten meal deposit xanthophyll pigments in the muscle tissue, resulting in a yellow colour in fillets (Gatlin *et al.*, 2007)

Phytic acid (PA), myoinositolhexa phosphate, is a naturally occurring compound in maize that makes up 1.5% kernel and 60% to 90% kernel phosphate (Lott *et al.*, 2000; Bohn *et al.*, 2008). Although PA is essential for kernel germination and phosphate storage, it can adversely affect the bioavailability of kernel minerals essential for human health and animal (Raboy, 2003).

In addition to PA chelation, dietary fiber also contributes to low iron bioavailability in maize. High intakes of organic acids, such as ascorbic and citric acids, in concordance with high-fiber-wholegrain maize meal (3 mg iron/100 g) increases iron bioavailability by curtailing iron's binding affinity to intrinsic kernel fibers in human and animals (Reinhold *et al.*, 1981).

PA can be treated with phytase enzyme to improve the use of plant ingredient in animal feed, for example in rainbow trout, the phytase supplemental increases total phosphorus digestibility of canola meal from 12% to 42% (Cheng and Hardy, 2002). However, PA is not considered as really serious challenge in maize meal (Gatlin *at al.,* 2007). In comparison with other locally available ingredient in Northern upland region of Vietnam, maize meal has much lower in fiber content (1.94% verse 13.26% (rice bran)) (Hung *et al*., 2005a,b).

Use of maize in animal feeds in Northern upland region of Vietnam

Maize is cultivated in a wide area of 502,000 ha, constituting about 45% total nationwide maize area. Its plant and grain is a suitable source as forage for livestock in the region. Reportedly, maize crop of one hectare produces 15 tons trunk, excluding corncob (Tuan *et al.,* 2008). This is commonly served as forage for local ruminant through the year, especially in winter seasons to solve feed shortage problems during this period (Huyen *et al.,* 2010). The ration used varies between sub-regions, about 72.78% and 21.80% total trunk in Northern-west and Northern, respectively (Tuan *et al*.,2008). The crop is known as palatability and relatively high nutritive value (Dongmeza *et al*., 2009; Dongmeza *et al*., 2010; Amin, 2011). Moreover, maize is commonly used as fodder stover or silage for livestock (Christopher *et al*., 1966). The use of maize fodder is found in the semi-arid and also in some locations where maize have not readily reached mature stage (John and Warren, 1967). The use of this plant, mainly leaves, is also applicable to pond aquaculture, i.e. grass carp (*Ctenopharyngodon idella*). It is known that maize leaves account for 8.4% of the total nitrogen (protein) input to the ponds in the region. It contains high ash content (11.01%), low acid insoluble ash proportion (6.35%), and is considered as potentially good source of minerals for fish (Dongmeza *et al*., 2009, 2010). In fresh type, maize leaves could support the growth of *C. idella* (Dongmeza *et al*., 2010). Therefore, this becomes the most important plant-derived feedstuff, in addition to banana, cassava (Pucher *et al*., 2013). It is however recommended to avoid feeding dried maize leaves to fish, because this feed results in a slow growth of fish, use of this could rather come to other animals (ruminants) (Dongmeza *et al*., 2010).

In Vietnam, maize has been increasingly used in commercial diets of poultry and pigs since period 1980 - 1990, when rice production fully met domestic demand. Since 1990, the animal husbandry sector has grown quickly and the demand for maize as animal feed has been steadily increased (Minh *et al*., 2004; Dao *et al*., 2005; Thanh and Neefjes, 2005). In particular, the share of maize produced on-farm for feeding livestock increased from 39% in 1993 to 55% in 1998, and for the poorest 20% of maize growers this share increased from 26% in 1993 to 46% in 1998. The investments of big animal feed companies in processing facilities in Vietnam strongly stimulated maize demand (Dao *et al*., 2005). Main of domestic maize production is originated from Northern upland region of Vietnam (accounting for approximate 37% total national maize production) (GSO, 2012). Maize as feedstuff has been widely used in many animal feeds. Local people in Vinh Phuc province (northeast area) was employed maize trunk, including fresh and fermented type as feed for cattle and dairy cow due to these forages were locally abundant (production of 15,331 tons, covering a total cultivation area of 3,407 ha in 2002) (Tuan and Trach, 2003). Moreover, nutrients of maize stover could be improved by urea (3%) application when feed to cow gilts, as well as this treatment might save feed cost and help local farmers to overcome the feed shortage in winter (December to March) (Martin *et al*., 2004; Tuan and Son, 2004).

In addition to maize plant forage, maize meal has been studied in animal feeds and in formulation of some animal feeds, maize are included at high levels. For example, in the experiment to determine suitable energy and protein levels for weaned pigs, the content of maize meal was largely varied, ranging 47.6 - 62.3% (Hong *et al*., 2003). In another experiment on pig, inclusion of 22.5% maize meal (cooked and fermentable incubated types) was observed (Mui, 2006). Eleven maize cultivars originated from northern of Vietnam were collected and determined chemical composition and metabolized energy (ME) in poultry by direct method. These included Bioseed 9723, Bioseed 9681, Bioseed 989, DK 888, LCH 9, LVN4, LVN10, Q2, Pacific 11, Pacific 60 and Silidim which were cultivated in northern area and some were used in feed industrial mills in Vietnam. It was concluded that different maize varieties had their different chemical composition and the ME used by poultry ranged 3375 – 3895 kcal/kg (dry matter) (Son *et al*., 2009). Huyen *et al*. (2012) conducted trials on local yellow cattle by testing four different feeding regimes. The results indicated that fixed ration feeding included maize meal (5 kg natural grass, 1 kg maize meal, and urea-treated rice straw *ad lib.*) could be profitable for large farmed yellow cattle in term of growth and net benefit.

In maize mill process industry, a large amount of residue are found and considered as potential feedstuff for animal farming industry. However, the use of these, so far, has not been reported in Vietnam. In Thailand, this is relative nutritive due to high level of nutrients (88.13% DM, 10.93% CP, 12.52% CF, 4.59% EE, 3.54% Ash, 57.79% NDF, 15.26% ADF, and 7.86% ADL) and included in diets for beef cattle at levels of 0, 20, 40 and 60% (Surapun and Choke, 2013).

Furthermore to leaves, maize meal is commonly fed to fish in small-scale pond farming. It is an important feed ingredient in aquaculture sector and provides valuable carbohydrate and energy sources for non-carnivorous feeding species. The incorporation level of maize meal in aquatic animal diets largely depends on processed products and targeted fish species. It can be incorporated in omnivore's feeds at 30 % corn meal and about 60 % maize bran (Chiou and Ogino, 1975; Law, 1986; Hertrampf and Piedad-Pascual, 2000) and up to 67% cooked grain in Central Vietnam (Tram, 2010).

Maize is conventionally cultivated over the hillsides, and considered the main rain-fed crops with cash generation, the majority of the harvested products, grains (62.2%) are traded to the lowlands through local traders for the animal food processing aims (Ha *et al.,* 2004; Steinbronn, 2009). The rest of 37.8% is stored mainly for livestock feed (28.5%), following by for human diets (9.0%) and for seed (0.3%) (out of the 37.8%).

In regard to forage, maize powder is used as instant feed for fish pond, dried spindles is occasionally served as firewood, and green spindles are fed to ruminant, moreover chickens and ducks are additionally fed maize and other feedstuffs, such as paddy, rice bran, cassava root fractions (Pucher *et al*., 2013). In some locations of Northwest, corn meal is used as additional concentrated feed, in supplementation with premix, for cattle in large farms (Huyen *et al*., 2010). The utilization of local maize meal in diets for fish in the region has been studied by some authors, Hung *et al*. (2015a) tested growth performance and feed utilization of black carp (*Mylopharyngodon piceus*), a high economic and nutrient value fish in the region, fed diets consisting of different inclusion levels of maize meal, the result showed that 20% maize meal in diet is the most suitable for black carp. This level is lower than mentioned that in omnivorous and herbivorous fish, because these species could use carbohydrate in maize better than in black carp, a carnivorous fish (NRC, 2011). Thu (2012) and Tuan (2010) confirmed this view. The former author found that maize meal derived from Son La province (in the Northern west) was well digested by grass carp for dry matter (88.96%), protein (84.89%), lipid (80.6%), while the latter author indicated that the incorporation level of that ranged from 15 - 50.3% in common carp diets formulated from locally ingredients. Although experimental parameters of fish fed these diets were not superior compared with fish meal base diet, the higher profit (feed cost per fish production (kg)) was confirmed. These views indicate that using local maize in diets for fish seems to be the most feasible due to their availability and cheapness. Maize meal like other cereals contains high content of carbohydrate, which is not well digested by carnivorous fish (NRC, 2011). Hung *et al*. (2015b) confirmed this view, authors found that the ability of black carp for corn meal nutrient digestions is relatively lower than that of grass carp reported by Thu (2012). To increase the digestibility of this nutrient, the simple cook is applied. Robinson *et al*. (2001) found that catfish can digest about 65% of uncooked maize starch when fed a diet containing 30% maize, while cooking increases the digestibility of maize starch to about 78%. Moreover, the extrusion processing of corn meal was proven to be increase growth, feed, nutrient efficiencies of dietary gross energy in rainbow trout (*Oncorhynchus mykiss*), gilthead sea bream (*Sparusaurata*) (Pfeffera *et al*., 1991; Venoua *et al*., 2003).

Conclusion

Chemical compositions of maize meal derived from Northern Upland region of Vietnam, were relatively similar among samples studied by various authors. Maize meal in the region has been widely used in livestock feed industry and in researches, this could be use as cheap and available feed source.

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