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REVIEW

Potentials of non-conventional protein sources in poultry nutrition

Olarotimi, O.J.[@] and Adu, O.A.

Department of Animal Production and Health. Federal University of Technology Akure. Akure. Ondo State. Nigeria.

ADDITIONAL KEYWORDS

Moringa oleifera.
Leuceana leucocephala.
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Crude protein.
Antibiotic.

SUMMARY

This paper reviewed research on the use of non-conventional protein sources of plant origin for poultry in Nigeria and other neighbor countries. As the cost of compounded feed continues being a burden for the Nigerian farmers due to the current high cost of conventional protein sources such as fishmeal, groundnut cake and soybean meal, it is very urgent to explore the potentials of non-conventional alternative sources of protein, especially the leaf meals of some plants, such as *Moringa oleifera*, *Leucaena leucocephala*, *Manihot esculenta*, *Carica papaya* and other leguminous fodders which can, to some extent, replace the inclusion of the conventional sources of proteins. These non-conventional alternative protein sources have excellent nutritive value and therapeutic properties. Their crude protein contents are excellent. It is apparent from the previous several studies that inclusion of these non-conventional protein sources in poultry diets improves performance of chickens in terms of growth rate and egg production. However, their recommended inclusion levels should strictly adherein order to avoid any form of deleterious effects they may likely confer on poultry. For instance, the up to 10% inclusion of *Moringa oleifera* leaf meal (MOLM) in the diets of laying hens has been regarded to be safe. Hence, their inclusion in poultry feeds without posing any deleterious effects to the birds' performances as well as the consumers of the products, and ultimately, leading to better profitability on the part of the farmers, will be a novelty.

Potenciales de las fuentes no convencionales de proteína en la alimentación de animales no rumiantes

PALABRAS CLAVE ADICIONALES

Moringa oleifera.
Leuceana leucocephala.
Manihot esculenta.
Proteína bruta.
Antibióticos.

RESUMEN

Este trabajo revisa las investigaciones sobre el uso de fuentes no convencionales de proteína de origen vegetal para la avicultura en Nigeria y otros paises vecinos. Como el coste de los piensos compuestos continua siendo una carga para los granjeros nigerianos debido al alto coste actual de las fuentes convencionales de proteína tales como harina de pescado, torta de cacahuete y harina de soja, es muy urgente explorar los potenciales de fuentes alternativas no convencinales de proteína, especialmente harinas de hojas de algunas plantas, tales como *Moringa oleifera*, *Leucaena leucocephala*, *Manihot esculenta, Carica papaya* y otros piensos leguminosos los cuales pueden, de alguna forma, sustituir la inclusión de fuentes convencionales de proteína. Esas fuentes alternativas no convencionales tienen un excelente valor nutritivo y propiedades terapéuticas. Sus contenidos de proteína bruta son excelentes. Resulta aparente por varios estudios previos que la inclusión de esas fuentes proteícas no convencionales en las dietas avícolas mejora el rendimiento de los pollos en término de tasa de crecimiento y producción de huevos. Sin embargo, sus niveles de inclusión recomendados deben de ser estrictamente ajustados para evitar cualquier efecto deletéreo que pueda tener sobre los pollos. Por ejemplo, la inclusión de la harina de hojas de *Moringa oleifera* (MOLM) hasta el 10% en dietas de gallinas ponedoras se ha comprobado que es segura. Por lo tanto, será una novedad su inclusión en alimentos avícolas sin producir efectos nocivos para el rendimiento de las aves así como para los consumidores de los productos y, finalmente, dando lugar a mejores beneficios de los granjeros.

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Correspondencia a los autores/Contact e-mail:
joemuyi@gmail.com

INTRODUCTION

Animal production has been severally highlighted as very pivotal to food security and the development of any nation. Ending poverty and hunger as well as improving health is one of the key goals of the United Nation's Sustainable Development Goals (SDGs) officially known as *Transforming our world: the 2030 Agenda for Sustainable Development* (UN, 2014). To achieve these goals, roles of animal production cannot be relegated to the background. Nigeria, with population of about 182 million as of 2015 (PRB, 2015), still has over 70% of the populace living on less than a dollar a day (Watts, 2006). By the year 2050 the projected population will be 397 million making Nigeria sitting as the 4th most populous country on earth after India, China and the United States (PRB, 2015). With this in view, Nigeria is threatened with the problem of food insecurity and poverty (Bamaiyi, 2013). Therefore, Intensification and development of the animal production sector of the economy in addition to other sectors will play a vital role in complimenting the population growth of Nigeria. An average Nigerian still consumes far less animal protein than the recommended daily consumption. Average daily protein intake in Nigeria is less than 9 g of animal protein per capita per day as compared to over 50 g per capita per day in North America and Europe (Boland *et al.,* 2013). FAO recommendation for daily protein consumption is put at 60 g per person out of which 35 g is expected to be from animal sources (FAO, 2002). However, Adetunji and Adepoju (2011) asserted that the average per capita protein intake in Nigeria was 51.7 g from which only 8.6 g came from animal sources, where as in developed countries, the average per capita protein intake was over 70 g with more than 55 g of animal protein. To alleviate this situation, practice of animal production in all entireties both at family and commercial levels must be explored.

As in the developed and other developing economies of the world, the non-ruminant animal production especially the poultry industry plays a pivotal role; a predominant source of animal protein both in the form of eggs and lean meat production. More than 70% of the cost of production in the poultry industry is for feed provision, and hence, the profitability of this industry depends largely on the quality and economics of feed production (Afolayan and Afolayan, 2008; Banson *et al*., 2015). Expansion of the industry will therefore mainly be determined by the sufficient availability and affordability of good quality feed for the birds and subsequently good poultry products, such as eggs and meats for the consumers (Adejimi *et al.,* 2011). For intensive enterprise, inadequacies in nutrients supply often lead to a drop in egg production as well as decline in growth performance on the part of broilers for meat production.

The bulk of the feed cost is attributed to the cost of protein sources such as groundnut cake, fish meal and soybean meal (Adeniji, 2008 and Dieumou *et al.,* 2013). Prices of these conventional protein sources have soared so high in recent times that it is becoming uneconomical to use them in poultry feeds (Esonu *et al.,* 2001). There is need therefore to look going by the current incessant occasion of rising prices and scarcity of feeds ingredients especially those of plant protein sources; several researches had been geared towards the direction of the non-conventional, locally available and cheap sources of feedstuffs particularly those that do not attract competition in consumption between humans and livestock with adequate potentials for improving poultry and other non-ruminant animal performance at very competitive and marginal costs. Very crucial among those non-conventional feed protein sources are leaf protein concentrates (Ebenebe *et al.* 2013). For example, Farinu *et al*. (1999) reported that of cassava (*Manihot esculenta)* leaf while *Leuceana leucocephala* has equally been researched and reported by Mellau (1999) and Bhatnagar (1996). Onunkwo and George (2015) reported that non-conventional feed stuff often reduces feed cost and hence higher profitability.

Non-conventional ingredients as protein source

Several authors have highlighted the proximate analyses of many non-conventional protein sources which can be used in poultry production. Sarwatt *et al.* (2004) reported Moringa (*Moringa oleifera)* leaves as potentially inexpensive protein source for animals with an average 80% dry matter content, 29.7% crude protein, 22.5% crude fibre, 4.38% ether extract, 27.8% calcium and 0.26% phosphorus while Yameogo *et al.* (2011) reported that, on a dry matter basis, *Moringa oleifera* leaves contained 27.2% protein, 5.9% moisture, 17.1% fat, and 38.6% carbohydrates. *Leuceana leucocephala* leaves were reported to contain 25.9% crude protein, 40% carbohydrate, 2.36% calcium, 0.23% phosphorus and 536 mg/kg β-carotene (Ojo and Fagade, 2002). Result of proximate analysis of neem (*Azadirachta indica)* leaves showed that neem leaf meal had 20.68% crude protein, 16.60% crude fibre, 4.13% ether extract, 7.10% ash and 43.91% nitrogen free extract (Esonu *et al*., 2006). Cassava (*Manihot esculenta*) leaf with 26.3% crude protein, 19.7% crude fibre, 7.3% fat and 5.5% moisture and *Gliricidia sepium:* 22.9% crude protein, 17.15% crude fibre, 8.8%fat and 6.7% are other potential non-coventional ingredients that can be included in poultry feeds (Nnaji *et al.* 2012). Pawpaw (*Carica papaya*) leaf is also a potential source with proximate analysis: 26.3% crude protein, 14.8% crude fibre and 6.8% moisture (Obwanga, 2010). Sun *et al.* (2014) also reported that of Sweet potato (*Ipomea batata)* leaf meal (IBLM). The leave meal was reported to have a high protein content of between 26 to 33%, with high amino acid score (Hong *et al.* 2003).

Ansari *et al* (2012) reported that broiler chicks fed on diets containing up to 2.5 g/kg neem (*Azadirachta indica)*leaf meal (AILM) had higher ($p<0.05$) packed cell volume (PCV) values, red blood cell (RBC) counts, white blood cell (WBC) counts, hemoglobin (Hb) and erythrocyte indices without any deleterious effects than birds fed the control diets. They also concluded that the dietary supplementation of *Azadirachta indica* leaf meal may lead to the development of low-cholesterol chicken meat. Neem leaf meal (AILM) can also be included in the diets of the laying birds up to an optimum level of 8% without any negative impact on the internal egg quality and serum biochemical indices as well as on the final consumer of the products (Olabode and Okelola, 2014).

Gadzirayi *et al.* (2012) reported that inclusion of *Moringa oleifera* meal (MOLM) as protein supplement in broiler diets at 25% inclusion level produces broilers of similar weight and growth rate compared to those fed under conventional commercial feeds ($p>0.05$). MOLM was also used at levels of up to 6% of the diet of growing layer chicks, up to 10% of the diet of laying hens, and up to 5% of the diet of broilers without deleterious effects on performance (Abbas 2013). Moringa undecorticated seed powder was also adjudged to be suitable in amounts of up to 1.5% of the diet of broilers during the finisher period, but not during the starter period (Talha and Mohammed, 2012).

Kakengi *et al.* (2003) reported that MOLM was substituted for sunflower seed meal as a protein source

Table I. Proximate composition of some non-conventional protein sources (Composición nutritiva de algunas fuentes no convencionales de proteina).

Leaf meals	Moisture	Crude Protein	Crude Fibre	Ether Extract	Ash	NFE	References
MOLM	23.47	27.51	19.25	2.23	7.13	20.41	Ibok *et al.*, 2008
AILM	7.58	20.68	16.6	4.13	7.1	43.91	Esonu *et al.*, 2006
LLLM	8.65	23.44	14.3	6.4	11.2	36.01	Zanu *et al.*, 2012
MELM	5.5	26.3	19.7	7.3	8.9	32.3	Nnaji *et al.*, 2012
GSLM	6.7	22.9	17.15	8.8	6.2	31.6	Nnaji *et al.*, 2013
CPLM	6.8	26.3	14.8	3.5	10.1	38.5	Obwanga, 2010
IBLM	11.3	25.66	12.76	3.06	12.11	35.11	Sun *et al.*, 2014

MOLM: *Manihot esculenta* leaf meal; AILM: *Azadirachta indica* leaf meal; LLLM: *Leuceana leucocephala* leaf meal; MELM: *Manihot esculenta* leaf meal; GSLM: *Gliricidia sepium* leaf meal; CPLM: *Carica papaya* leaf meal; IBLM: *Ipomea batata* leaf meal.

for layers. Parameters studied were feed intake, dry matter intake, weight, percentage hen day production and feed conversion ratio. The result of the study suggested that MOLM could totally replace sunflower seed meal up to 20% without any noticeable side effects on the laying birds. Pawpaw (*Carica papaya*) leaf meal (CPLM) was reportedly incorporated at 2% level in the diet of finishing broilers; a significant improvement of 14% in growth performance was observed compared to the birds on the control diet, carcass and organoleptic indices of the birds were equally recorded with corresponding more economic returns as observed by the significantly lower feed cost/kg gain (Onyimonyi and Onu, 2009).

Mutayoba *et al.* (2003) reported that *Leucaena leucocephala* meal (LLLM) at 5% had no adverse effect on performance of growing layers but higher inclusion levels affected performance regardless of the dietary energy level**.** On the other hand, Ayssiwede *et al.* (2010) reported that the inclusion of LLLM in the diet at 21% level had no significant adverse effect on feed intake, average daily weight gain, feed conversion ratio and nutrients utilization (except ether extract) of adult indigenous Senegal chickens but significantly ($p<0.05$) improved the crude protein and metabolizable energy utilization in birds fed at 7% level inclusion. At 5% inclusion level, cassava *(Manihot esculenta)* leaf meal (MELM) in broiler finisher diets was reported to confer a significant ($p<0.05$) increase in feed intake, body weight gain, feed conversion ratio and organ weight of birds without any deleterious effects (Iheukwumere *et al.*, 2008) over those with 10 and 15% inclusion levels. Kagya-Agyemang *et al.* (2007) recommended an inclusion level of not more than 5% *Gliricidia sepium* leaf meal (GSLM) in broiler diets as he recorded a better carcass dressing percentage at this level while a progressive decrease in carcass dressing percentage was observed at higher inclusion rate with 15% inclusion level having a significantly ($p<0.05$) lowest carcass dressing percentage. However, there was a corresponding increase in the intensity of yellow pigmentation of the skin, shanks, feet and beaks of birds. The feed intake and body weight gain of broiler birds fed on diets containing sweet potato (*Ipomea batata*) leaf meal (IBLM) up to 10% inclusion was similar with the control group, but, beyond 10% inclusion the feed intake and body weight gain were reduced significantly compared with the control group (Tsega and Tamir, 2009).

NON-CONVENTIONAL INGREDIENTS AS VITAMIN AND MINERAL SOURCES

Aside the rich protein content present in the non-conventional protein source, some of them are notable for rich content of vitamins and minerals. For instance, it has been reported that moringa leaves contained up to 20.0% Ca, 1.37% Mg, 0.20% P, 1.32% potassium K, 0.03% iron Fe and 0.87% S (Ndubuaku *et al.,* 2015). Moringa also contains high levels of vitamins A, B, C and E in the dried leaves. The leaves are very rich in β-carotene and ascorbic acids (Ibok *et al.,* 2008). LLLM is also reported to be very rich in xanthophyll pigments to the tune of 741-766 mg/kg DM (dry matter) (DMello and Taplin, 1978). These pigments are very desirable for the egg yolks and the skin of broilers. Cassava leaves were also reported to be rich in minerals such as iron, zinc, manganese, magnesium, and calcium as well as vitamins in the likes of niacin, riboflavin, thiamin, Vitamin A and Ascorbic acid (Wobeto *et al.,* 2006). CPLM is high in vitamins (A, B1, B2and C) and minerals (Ca, K, P, and Fe). Furthermore, it contains papain which aids digestion thereby releasing free amino acids which enhances growth (Chaplin, 2005). AILM was also reported to possess high amino acid content with good mineral profile and vitamins A, B2, C and E (Ekenyem and Madubuike, 2006).

MEDICINAL EFFECTS OF NON-CONVENTIONAL INGREDIENTS

It has been recommended that the use of penicillins, tetracyclines, tylosin, and sulfonamides as growth promoters are discontinued (Patrick *et al*., 2003). Then, it is necessary for poultry farmers to embrace rearing birds without using antibiotics and other drugs that can leave residues on the final products which could be of health risk to the consumers of such products. Hence, use of plants and their extracts which can improve feed intake and confer antimicrobial, coccidiostatic or antihelmintic effects on animals will be a novelty. Chakravarty and Prasad (1991) reported that broilers given neem leaf extract in water showed significant ($p<0.05$) nutrient utilization and weight gain. It has been equally emphasized that neem played an important role in enhancing the immune system of the body (Landy *et al.* 2011). Durrani *et al*. (2008) recorded increase in antibodies against Newcastle and infectious bursal disease viruses when neem is incorporated in poultry feeds. It is on record as well that water based extract (10%) of neem leaves has anti-viral effects against, fowl pox, infectious bursal diseases (IBD) and Newcastle disease virus (NDV) and it significantly enhances the antibodies production against the IBD and NDV (Sadekar *et al*., 1998). Neem at 7 g/kg in diet was found to give highest antibody titers against NDV (Jawad *et al.,* 2013). Hence, it was concluded that neem plays an important role in triggering a better humoral immune response against new castle and infectious bursal disease viruses. Ogbuewu *et al.* (2011) also reported that in the poultry production, aflatoxicosis contracted from contaminated poultry feed could be prevented using neem leaves. Neem leaf extract inhibits the production of aflatoxin by *Aspergillus parasiticus* (Allameh *et al*., 2002). The processed neem cake was also reported to have wormicidal activity and can be used as an excellent poultry feed (Thampatti, 2001). Bonsu *et al.* (2012) reported that the broiler diets containing *Azardirachta indica* leaf meal controlled coccidiosis, worm infestation and respiratory infections effectively in those birds fed the diets compared with the control.

Moringa oleifera has been reported to possess anticoccidial properties and could, therefore, serve as a useful alternative product for the control of avian coccidiosis in poultry production (Ola-Fadahunsi and Ademola, 2013). Makanjuola *et al.* (2014) conducted an experiment to determine the effect of MOLM as substitute to antibiotics on the performance and blood parameters of broiler chickens. The results of the study showed that most of all the parameters measured in birds fed diets containing MOLM compared well with those placed on an antibiotic and replacing enrofloxacin with MOLM reduced the cost of production of broilers significantly.

Pawpaw leaf extract has been reported to have medicinal effects such as a protective effect against gastric ulcers (Indran *et al.,* 2008), antibacterial activities (Zakaria *et al.*, 2006), contraceptive and anti-inflammatory effects (Owoyele *et al.,* 2008). The medicinal properties of sweet potato was severally stressed by Parle and Monika (2015) to include anti-cancer, anti-diabetic, anti-inflammatory, anti-oxidant, anti-bacterial, anti-fungal, anti-viral, anti-ulcer, hepatoprotective, wound healing, and immunomodulatory activities. With all these attendant benefits, these leaf meals will definitely play a vital role in poultry health and general well-being, thereby, having the potentials of reducing the total cost to be incurred on medications and vaccinations. There have been reported studies, as well, on the anthelmintic and antidiarrheal activities of the cassava leaf extracts in animal production (Bahekar and Kale, 2015).

NON-CONVENTIONAL INGREDIENTS HAS ANTINUTRITIONAL FACTORS (ANFS)

However, the utility of non-conventional protein source as animal feed supplements is limited by the presence of anti-nutritional factors (ANFs). In monogastric animals, such as pigs and poultry, tannins are noted for poorer feed conversion efficiency (FAO, 1996). It has been reported that, in poultry, tannin levels from 0.5 to 2.0 % in the diet can depress growth and egg production, while levels from 3 to 7 % can cause death (Martens *et al.,* 2012). Worku (2016), however, reported that moringa leaves are free from anti- nutrients except for saponins and phenols. Niranjan *et al*. (2008) reported that the tannin concentration in neem (*Azadirachta indica)* leaves is comparably lesser than what is obtainable in *Leucaena leucocephala* and way below the level that will depress feed intake while the lignin level is within the range of 4.2 to 11.7 found in *Leucaena leucocephala* as reported by Garcia *et al.* (1996).

Condensed tannins are usually not toxic, but hydrolysable tannins can cause liver and kidney damage, and death (Makkar, 2007). Conversely, tannins are antioxidants and can improve resistance to heat stress (Liu *et al*., 2011). To maximize the potentials of these sources of proteins, treatment that will lead to reduction or total elimination of the ANFs without compromising the protein content will be a welcomed development. Heat treatment such as sun- and oven-drying, roasting, autoclaving, and boiling, which usually reduces the content of heat-susceptible ANFs, could be employed before the leaf meals are prepared. Phuc *et al.* (1995) reported that sun-dried cassava leaves contained 20 mg/kg hydrogen cyanide in the leaf meal compared with 190 mg/kg in the meal of fresh leaves. Martens (2012) also reported laying hens fed sun-dried *Gliricidia sepium* performed better than those fed with the oven

Table II. Recommended inclusion of some leaf meals in poultry diets (Niveles de inclusión recomendados para algunas harinas de hojas en dietas aviares).

Leaf meals	Inclusion (%)	Birds' diet	References
MOLM	20-25	Broiler, Layers	Gadzirayi *et al.,* 2012
AILM	0.25	Broiler chicks	Ansari *et al.,* 2012
LLLM	5-7	Layers	Mutayoba *et al.,* 2003
MELM	5	Broiler	Iheukwumere *et al.,* 2008
GSLM	5	Layers	Kagya-Agyemang *et al.,* 2007
CPLM	2	Broiler	Onyimonyi and Onu, 2009
IBLM	10	Broilers	Tsega and Tamir, 2009

MOLM: *Manihot esculenta* leaf meal; AILM: *Azadirachta indica* leaf meal; LLLM: *Leucaena leucocephala* leaf meal; MELM: *Manihot esculenta* leaf meal; GSLM: *Gliricidia sepium* leaf meal; CPLM: *Carica papaya* leaf meal; IBLM: *Ipomea batata* leaf meal.

Table III. Minerals and vitamin content of some non-conventional protein sources (Contenidos de vitaminas y minerales en algunas fuentes no convencionales de proteínas).

Compositions	MOLM	AILM	MELM	LLLM	GSLM	CPLM	IBLM
Vitamins (mg/g)							
Thiamin (B1)	0.0264	0.018	0.185	0.04	0.052	0.043	0.156
Riboflavin (B2)	0.2005	0.095	0.475	0.09	0.029	0.014	0.345
Niacin (B3)	0.082	0.058	2.05	0.054	0.375	0.038	1.13
Ascorbic acid (C)	0.173	0.198	0.902	0.64	1.793	0.311	1.417
Vitamin A	0.189	0.198	0.88	0.536	0.037	0.04	0.75
Minerals (mg/g)							
Calcium	25.6	18.3	11.9	10.7	11.9	34.6	12.4
Total Phosphorus	3.3	2.5	3.7	2.1	2.3	3.5	3.1
Iron	0.262	1.012	0.4	0.261	0.153	0.011	0.147
Potassium	14.6	7.23	12.5	18.9	27.1	30.4	14.2
Sodium	0.3	0.19	0.6	0.2	0.4	0.018	3.7
Magnesium	4.1	3.1	7.3	3.9	4.5	8.5	7
Copper (ppm)	11	13	29	13	12	0.00	11
Zinc (ppm)	33	114	25	30	35	10.97	45

MOLM: *Manihot esculenta* leaf meal; AILM: *Azadirachta indica* leaf meal; LLLM: *Leucaena leucocephala* leaf meal; MELM: *Manihot esculenta* leaf meal; GSLM: *Gliricidia sepium* leaf meal; CPLM: *Carica papaya* leaf meal; IBLM: *Ipomea batata* leaf meal.

References:(i) Minerals: Feedipedia (2015); (ii) Vitamins: Montagnac *et al.* (2009); Atangwho *et al.* (2009); Nwofia *et al.* (2012); Bhowmik (2008) and Duke (1986).

dried legume according to Montilla *et al*. (1974). In SPLM, the antinutritional substances are the protease inhibitors and invertase (Apata and Babalola, 2012). These substances can be deactivated by various processing methods like oven or sun-drying, boiling or steaming and grinding prior to inclusion in animal feeds.

Despite the high level of crude protein, vitamins and nutritionally valuable minerals in cassava leaf, the nutritional limitations of cassava leave include the hydrogen cyanide (HCN) content, low digestible energy, bulkiness and possibly the high tannin content (Apata and Babalola, 2012). The presence of the cyanogenetic glycosides poses a great limit to its use in poultry feed. However, the leaves could be processed before its inclusion in poultry diets. The two most employed processing methods are sun drying and ensiling. In poultry, it was reported that broilers could tolerate diets containing 141 mg total cyanide kg^{-1} without any negative effects on growth performance (Ravindran *et al.*, 1986).

CONCLUSIONS

Considering the potential nutritional benefits available in some fodders as non-conventional protein sources as highlighted above, their inclusions at the recommended levels can make them best option as supplements for poultry production in order to profitably cut down on the quantity of conventional protein sources inclusion in feed production. Furthermore, the fact that the inherent anti-nutritional factors in them can be subjected to various processing methods will improve the quality and safety of these feed ingredients. If both farmers and livestock feed manufacturers can take advantage of the abundant availability of these materials in Nigeria and other neighbor countries, this will definitely impact positively on their profit margin as well as creating a business chain for those who will concentrate on the production of these ingredients in commercial quantities.

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