

## Effect of diet on live weight and egg weight of backyard hens during the rainy season

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**ABSTRACT.** The objective was to determine the effect of diet on live weight (LW) and egg weight (EW) of backyard hens (BH) during the rainy season in the Bajío region of the state of Michoacán, Mexico. Seventeen municipalities were sampled, where 101 BH (six hens/municipality) were captured and weighed and 101 eggs (six eggs/municipality) were harvested and weighed. The crops of the captured hens were removed Post-sacrifice, the organic content/crop (OCC) was classified and weighed by components, to later perform chemical compositional analysis. Data were analysed using generalised linear models and the differences between municipalities were obtained by the method of least squares means. The weight of the OCC ( $36.4 \pm 22.4$  g) was affected by the municipality ( $P < 0.001$ ), but not by the LW of the BH ( $P > 0.05$ ). Commercial feed ( $8.1 \pm 6.0$  g), grains: maize and sorghum ( $13.9 \pm 13.5$  g) kitchen waste ( $1.5 \pm 2.9$  g), herbaceous ( $0.6 \pm 0.9$  g) and insects ( $0.3 \pm 0.7$  g) were found in the crop. According to the commercial feed (COF) component, two feeding systems (FS) were identified: traditional FS, without COF and nontraditional FS, with COF. The diets of both FS were similar ( $P > 0.05$ ) in nutritional composition and do not meet the nutritional requirements of the hens. The LW ( $1.567 \pm 0.316$  kg) and EW ( $51.3 \pm 1.0$  g) of the BH cannot be completely attributed to the diet consumed during the rainy season.

*Key words:* backyard fowl, rural poultry, rural poultry feed.

**RESUMEN.** El objetivo del estudio fue determinar el efecto de la dieta sobre el peso vivo (PV) y peso del huevo (Phvo) de las gallinas de traspatio (GT) durante la época de lluvias en la región Bajío del estado de Michoacán, México. Se muestrearon 17 municipios, en donde se capturaron y se pesaron 101 GT (seis/municipio) y se recolectaron y pesaron 101 huevos (seis/municipio). Se extrajeron, postsacrificio, los buches de las gallinas capturadas, cuyo contenido orgánico/buche (COB) fue clasificado y pesado por componentes, para posteriormente realizar el análisis bromatológico. La información se analizó mediante modelos lineales generalizados y las diferencias entre municipios se obtuvieron por la metodología de medias de mínimos cuadrados. El peso del COB ( $36,4 \pm 22,4$  g) fue afectado por el municipio ( $P < 0,001$ ), mas no por el PV de GT ( $P > 0,05$ ). En COB se encontró: alimento comercial ( $8,1 \pm 6,0$  g), granos: maíz y sorgo ( $13,9 \pm 13,5$  g), desperdicios de cocina ( $1,5 \pm 2,9$  g), herbáceas ( $0,6 \pm 0,9$  g) e insectos ( $0,3 \pm 0,7$  g). De acuerdo con el componente alimento comercial (AC) se identificaron dos sistemas de alimentación (SA): SA tradicional, sin AC y SA no tradicional, con AC. Las dietas de ambos SA fueron similares ( $P > 0,05$ ) en composición nutricional y no cumplen con los requerimientos nutricionales de estas aves. El PV ( $1,567 \pm 0,316$  kg) y el Phvo ( $51,3 \pm 1,0$  g) de las GT no pueden ser completamente atribuidos a la dieta consumida durante la época de lluvias.

*Palabras clave:* alimentación avícola rural, ave de corral, avicultura rural.

### INTRODUCTION

According to FAO (2012), backyard poultry farming in Mexico and other emerging or underdeveloped countries, have serious problems in terms of increasing production efficiency. The main difficulty, according to Hernandez *et al* (2011), is that the nutritional requirements of the backyard hens (BH) are not established which implies real challenges due to the variability in hen nuclei genetics (*Gallus gallus domesticus*), environment, health and inputs (products and agricultural sub-products; as well as

herbaceous and insects that the fowls consume themselves) present in each region and each household<sup>1</sup>.

The lack of nutritional information for the BH nuclei is caused by the characteristics of this system, which in turn make difficult their study. The rural and indigenous families of Mexico developed this type of activity because the investment of money and material resources do not play an essential role, and the available resources of the rural housing and community are sufficient (Gutiérrez *et al* 2012). Lushmann (1998) observed that the survival and reproduction of the systems are determined not by the environment, but by intrinsic forces rooting in the “motives” of people, while Juárez *et al* (2008) established that, within the family, the reasons for poultry production are mainly focused on: economic needs, pleasure, tradition and savings, among others<sup>2</sup> (Aknola and Essien 2011). These

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<sup>1</sup> Juárez CA, Ortiz RR, Pérez SER, Gutiérrez VE, Val DA. 2008. Caracterización y modelación del sistema de producción avícola familiar. *Livest Res Rural Develop* 20. Accessed January 18, 2015, available at <http://www.lrrd.org/lrrd20/2/juar20025.htm>

<sup>2</sup> Moreki JC, Dikeme R, Poroga B. 2010. The role of village poultry in food security and HIV/AIDS mitigation in Chobe District of Botswana. *Livest Res Rural Develop* 22. Access February 15, 2015, available at <http://www.lrrd.org/lrrd22/3/more22055.htm>

reasons consequently cause the BH nuclei to show relatively low productive and reproductive levels. Therefore, incorporating feeding techniques and technologies, as well as prevention of diseases and predators is not expected (Mammo and Wude 2011, Yusuf *et al* 2014).

The main feed resources for BH are cereal grains (i.e., maize and sorghum), food waste, herbaceous and insects (Huerta *et al* 2011, Gutierrez *et al* 2012). However, the quantity and quality of these inputs depends on the availability in the house, season, crop cycle and life cycle of insects and other invertebrates<sup>3,4</sup>. According to Minh *et al* (2006) and Reta<sup>5</sup>, the time of the year plays a key role in the feeding of the backyard fowl, because during the rainy season the availability of the diet improves. The rainy season provides better conditions to increase the population of herbaceous and insects, improving live weight and productive performance which undoubtedly depends on the genotype, age and individual variation between hens (Source *et al* 2012).

In brief, the characteristics of the poultry production family system hinder the solution to its problems, as established by FAO (2012), and also the implementation of actions to overcome the limitations for its development<sup>6</sup>. Since these production systems are articulated in such a way that the biological component (hen) coexists with the man in a symbiotic relationship, and due to its management, having control on the different biological events that are inherent to the backyard poultry production is difficult<sup>1</sup>; specially regarding nutrition. Therefore, the objective of this study was to evaluate and relate the components of the diet of BH with live weight and egg weight during the rainy season in the Bajío region of the state of Michoacán, Mexico.

## MATERIAL AND METHODS

### RESEARCH LOCATION

The study was conducted during the rainy season (June-October) in the Bajío region, Michoacán state, Mexico, which is located between the coordinates 20° 9' north latitude and 101° 43' west longitude with a height of 1,690 masl. The temperature ranges between 16 and 22 °C and annual rainfall between 700 and 1000 mm (INEGI 2014). In this region, 101 family production systems were selected. The municipalities and communities where the systems were selected were determined based on: I) the inventory of the population of BH and II) quantity of systems per community and municipality. The municipalities analysed were Angamacutiro, Coeneo, Churintzio, Ecuandureo, Huaniqueo, Villa Jiménez, José Sixto Verduzco, Morelos, Numarán, Penjamillo, La Piedad, Panindícuaro, Puruándiro, Zináparo, Zacapu, Santa Ana Maya and Cuitzeo. Six communities were chosen from each municipality, in which the nuclei of backyard poultry production were selected based on: 1) average number of free-range hens (between 17 to 25 fowl/nuclei), 2) housekeeper availability to provide information and 3) a laying hen that could be identified to later collect the egg and capture the hen.

### RESEARCH ANIMALS

With the information provided by the housekeeper, 101 BH were captured and 101 eggs were collected (one per community = six per municipality) during the rainy season (June to October). Twelve BH were obtained per week during 8.5 weeks, between 12:00 and 17:00 hrs, to ensure the crop of the BH had the highest food content. Once the hens were captured, LW and EW were registered. Eggs were not stored for no more than 7 days. The LW and the EW of the BH was determined using a digital scale (Sartorius model BL1500, with a precision of  $\pm 1$  g). The hens were weighed and immediately sacrificed to collect the crops, according to the "Norma Oficial Mexicana" (NOM-003-ZOO-1995) for the humane slaughter of domestic animals.

### SAMPLES

The feeding information of the BH analysed was obtained by the chemical composition analysis of the crop content (n=101). Once the crop was removed, it was weighed and immediately placed in a plastic bag and identified. The bags were placed in a cooler and transferred to the Food Analysis and Animal Nutrition Laboratory of the Facultad de Medicina Veterinaria y Zootecnia, Universidad Michoacana de San Nicolás de Hidalgo. In the laboratory, the components of the diet found in the crop of each fowl were separated, identified and classified into 5 groups:

<sup>3</sup> Rashid MM, Islam MN, Roy BC, Jakobsen K, Lauridsen C. 2005. Nutrient concentrations of crop and gizzard contents of indigenous scavenging chickens under rural conditions of Bangladesh. *Livest Res Rural Develop* 17. Accessed February 10, 2015, available at <http://www.lrrd.org/lrrd17/2/rash17016.htm>

<sup>4</sup> Ruiz SC, Salaverría J, Valles C, Yépez, Herrera S. 2008. Comportamiento de gallinas criollas (gen Na) en un sistema semilibre y alimentadas con recursos alternativos en Yaracuy, Venezuela. *Livest Res Rural Develop* 20. Accessed June 12, 2015, available at <http://www.lrrd.org/lrrd20/5/ruiz20066.htm>

<sup>5</sup> Reta D. 2009. Understanding the role of indigenous chickens during the long walk to food security in Ethiopia. *Livest Res Rural Develop* 21. Accessed May 12, 2015, available at <http://www.lrrd.cipav.org.co/lrrd21/8/dugu21116.htm>

<sup>6</sup> Badubi SS, Rakereng M, Marumo M. 2006. Morphological characteristics and feed resources available for indigenous chickens in Botswana. *Livest Res Rural Develop* 18. Accessed March 15, 2015, available at <http://www.lrrd.cipav.org.co/lrrd18/1/badu18003.htm>

commercial feed (COF), grains (GS), kitchen wastes (KW), herbaceous (HS) and insects (IS). Once classified and identified by crop, they were dehydrated in a desiccation stove (Felisa Oven 292-D) at 65 °C for 24 hrs to obtain the weight/content as dry matter.

#### CHEMICAL COMPOSITION ANALYSIS

The physicochemical determination of the average crop content per municipality was done as follows: 10% of each component found was used, afterwards the components were mixed and ground in a porcelain mortar to obtain a homogenous mixture. The chemical composition analysis was done with 10 g of each mixture according to the technique described by AOAC (2005) and dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE), ash (A) and nitrogen free extract (NFE) were determined.

#### STATISTICAL ANALYSIS

The information gathered served to generate a data base was for statistical analysis using the methodology of categorical models (CATMOD) and general linear models (GLM) SAS Institute (2002). The difference between municipalities was obtained through the method of least square means (LS Means) SAS Institute (2002).

#### RESULTS

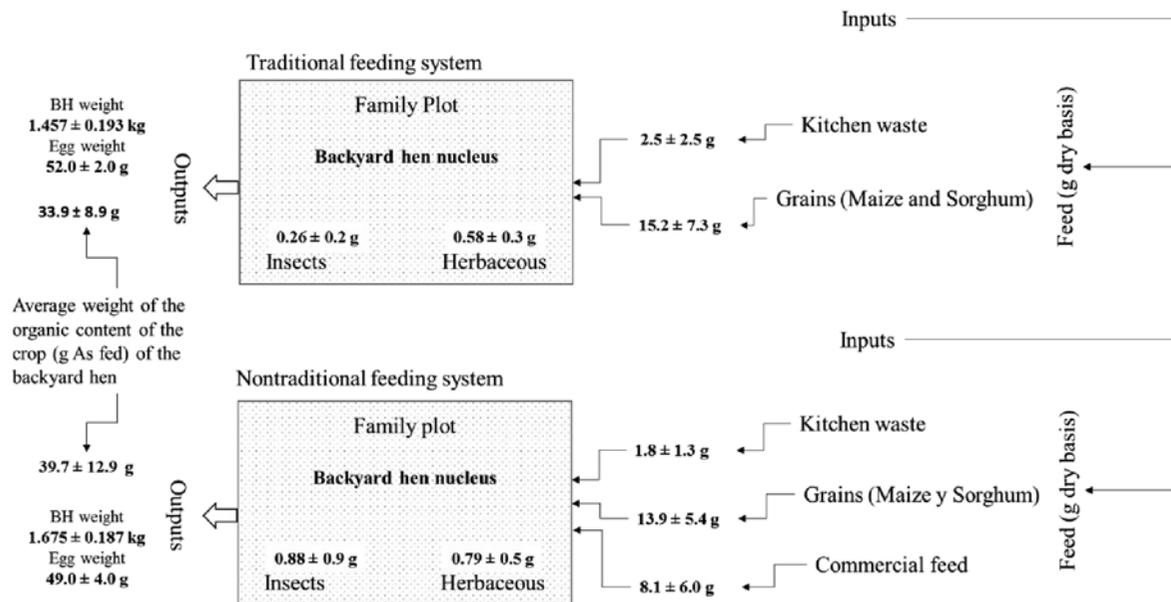
An important aspect in backyard poultry is the determination of components in the diet of the hen, because under the family production system (FPS) these fowls are

mainly free-range, feeding on what the backyard offer plus supplementation (grain and kitchen waste) offered by the owner. However, in this study the composition of the diet of the BH was determined through the crop content. In this regard, it was found that during the rainy season, the total crop weight (TCW) was  $52.7 \pm 25.8$  g. as fed (AF), while the organic content of the crop (OCC) was of  $36.4 \pm 22.5$  g dry matter basis (DM) (table 1). The average TCW and the OCC values were affected by the municipality ( $P < 0.001$ ) but not by the live weight (LW) of the BH ( $P > 0.05$ ), which was  $1.567 \pm 0.316$  kg.

In relation to the OCC during the rainy season, the following feed inputs and their quantities were found:  $8.1 \pm 6.0$  g commercial feed (COF),  $14.6 \pm 6.5$  g of grain (maize and sorghum) (GS),  $2.2 \pm 2.1$  g kitchen wastes (KW),  $0.7 \pm 0.4$  g of herbaceous (HS) and  $0.6 \pm 0.5$  g of insects (IS). Within this feed inputs, COF was found in 41.5% of the crops analysed and represented 31.4% of the TCW (table 1).

According to the COF input, the existence of two feeding systems within the FPS analysed was determined: a) traditional feeding system (TFS) and b) nontraditional feeding system (NTFS), because in the latter, COF was found in the crops analysed (figure 1).

Figure 1 shows that the main feed inputs of the diet in the TFS offered by the rural women during the rainy season were maize and sorghum grains ( $15.2$  g  $GT^{-1}$ ) and kitchen wastes ( $2.5$  g  $GT^{-1}$ ). The BH had the possibility to complement this diet with insects ( $0.58$  g  $GT^{-1}$ ) and herbaceous ( $0.26$  g  $GT^{-1}$ ). Regarding the NTFS, the feed inputs offered by the rural women were COF ( $8.1$  g  $GT^{-1}$ ) plus grains ( $13.9$  g  $GT^{-1}$ ) and kitchen wastes ( $1.8$  g  $GT^{-1}$ ).



**Figure 1.** Schematization of two family poultry production systems according to the type and quantity of feed inputs (dry basis) found in the crop of backyard hens in the Bajío region of Michoacán, Mexico, during the rainy season.

**Table 1.** Least squares means for the weight of the organic content of the crop and weight (g) of the components of the crop.

Municipality	OCC (AF) ( $\bar{x} \pm$ )	Weight of component (DM)				
		COF ( $\bar{x} \pm$ )	GS ( $\bar{x} \pm$ )	KW ( $\bar{x} \pm$ )	HS ( $\bar{x} \pm$ )	IS ( $\bar{x} \pm$ )
System with the implementation of COF (NTFS)						
Santa Ana Maya	38.5 ± 24.6	4.9 <sup>a</sup> ± 1.8	13.9 <sup>a</sup> ± 10.5	0.4 <sup>a</sup> ± 0.1	0.3 <sup>a</sup> ± 0.3	2.0 <sup>a</sup> ± 0.6
Cuitzeo	44.4 ± 22.0	1.4 <sup>a</sup> ± 0.6	13.2 <sup>a</sup> ± 13.2	3.9 <sup>a</sup> ± 5.7	1.3 <sup>a</sup> ± 1.3	0.2 <sup>a</sup> ± 0.2
Coeneo	18.7 ± 10.8	3.9 <sup>a</sup> ± 0.3	8.3 <sup>a</sup> ± 6.3	1.9 <sup>a</sup> ± 2.0	0.7 <sup>a</sup> ± 1.4	0.2 <sup>a</sup> ± 0.1
Puruándiro	53.3 ± 23.2	17.1 <sup>a</sup> ± 0.2	14.2 <sup>ab</sup> ± 9.1	0.1 <sup>a</sup> ± 0.0	0.8 <sup>a</sup> ± 0.7	2.4 <sup>a</sup> ± 3.1
Panindícuaro	50.1 ± 22.3	16.2 <sup>a</sup> ± 0.0	15.2 <sup>ab</sup> ± 12.0	1.4 <sup>a</sup> ± 1.1	1.5 <sup>a</sup> ± 1.8	0.8 <sup>a</sup> ± 1.0
Churintzio	26.1 ± 9.3	6.9 <sup>a</sup> ± 0.0	8.0 <sup>a</sup> ± 4.0	1.9 <sup>a</sup> ± 2.1	0.7 <sup>a</sup> ± 1.0	0.1 <sup>a</sup> ± 0.1
Numarán	47.2 ± 35.5	6.6 <sup>a</sup> ± 0.0	24.3 <sup>b</sup> ± 30.2	3.1 <sup>a</sup> ± 2.2	0.2 <sup>a</sup> ± 0.2	0.5 <sup>a</sup> ± 0.6
$\bar{x} \pm$	39.7 <sup>q</sup> ± 12.9	8.1 <sup>q</sup> ± 6.0	13.9 <sup>q</sup> ± 5.4	1.8 <sup>q</sup> ± 1.3	0.79 <sup>q</sup> ± 0.5	0.88 <sup>q</sup> ± 0.9
% respect to the OCC		31.4	54.0	8.1	3.0	3.4
Traditional feeding system (TFS)						
Huaniqueo	22.5 ± 21.8	–	17.0 <sup>ab</sup> ± 14.0	0.1 <sup>a</sup>	0.4 <sup>a</sup> ± 0.4	0.1 <sup>a</sup> ± 0.0
Morelos	40.4 ± 26.4	–	19.6 <sup>ab</sup> ± 15.1	6.0 <sup>a</sup> ± 5.8	0.9 <sup>a</sup> ± 0.9	0.1 <sup>a</sup> ± 0.0
Zacapu	42.8 ± 18.5	–	32.8 <sup>c</sup> ± 17.0	2.3 <sup>a</sup> ± 2.4	0.6 <sup>a</sup> ± 0.7	0.2 <sup>a</sup> ± 0.1
Ecuandureo	47.0 ± 13.9	–	12.5 <sup>a</sup> ± 8.4	7.2 <sup>a</sup> ± 4.6	1.2 <sup>a</sup> ± 0.8	0.4 <sup>a</sup> ± 0.3
José Sixto Verduzco	24.1 ± 17.4	–	9.6 <sup>a</sup> ± 12.4	4.4 <sup>a</sup> ± 5.2	0.5 <sup>a</sup> ± 0.4	0.2 <sup>a</sup> ± 0.2
Penjamillo	30.8 ± 23.3	–	17.1 <sup>ab</sup> ± 18.0	0.2 <sup>a</sup> ± 0.1	0.6 <sup>a</sup> ± 0.5	0.2 <sup>a</sup> ± 0.2
La Piedad	27.1 ± 13.3	–	12.3 <sup>a</sup> ± 10.0	1.5 <sup>a</sup> ± 1.6	0.2 <sup>a</sup> ± 0.2	0.2 <sup>a</sup> ± 0.2
Zináparo	27.5 ± 11.6	–	6.9 <sup>a</sup> ± 3.4	2.5 <sup>a</sup> ± 3.0	0.3 <sup>a</sup> ± 0.2	0.1 <sup>a</sup> ± 0.0
Angamacutiro	36.9 ± 12.9	–	9.4 <sup>a</sup> ± 7.0	1.4 <sup>a</sup> ± 2.3	0.2 <sup>a</sup> ± 0.2	0.8 <sup>a</sup> ± 1.2
Villa Jiménez	40.7 ± 9.6	–	15.2 <sup>ab</sup> ± 7.0	0.1 <sup>a</sup> ± 0.0	0.9 <sup>a</sup> ± 1.4	0.3 <sup>a</sup> ± 0.4
$\bar{x} \pm$	33.9 <sup>q</sup> ± 8.9	0.0 <sup>z</sup>	15.2 <sup>q</sup> ± 7.3	2.5 <sup>q</sup> ± 2.5	0.58 <sup>q</sup> ± 0.3	0.26 <sup>z</sup> ± 0.2
% respect to the OCC		0.0	82.1	13.5	3.1	1.4

OCC = Organic Content of the Crop; DM = Dry matter; AF = As fed; COF = Commercial Feed; NTFS = Non-traditional feeding system: with the implementation of COF; TFS = Traditional Feeding System; GS = Grains; KW = Kitchen Waste; HS = Herbaceous; IS = Insects.

<sup>a, b, c, d</sup> = Different literals indicate differences ( $P < 0.05$ ) within the column independent of the system.

<sup>q, z</sup> Different literals indicate differences ( $P < 0.05$ ) within the column between systems.

Nevertheless, the incorporation of COF in the BH diet, was not reflected in the weight of OCC, since this was the same in both feeding systems ( $P > 0.05$ ): 33.9 ± 8.9 and 39.7 ± 12.9 g AF, for TFS and NTFS, respectively.

Maize and sorghum grains represented the greater feed input found in the BH crop in both feeding systems studied: 13.9 and 15.2 g DM, for NTFS and TFS respectively. This averages were statistically equal ( $P > 0.05$ ). However, in proportion to the OCC, this averages represented 54.0 and 82.1% of the weight for NTFS and TFS, respectively.

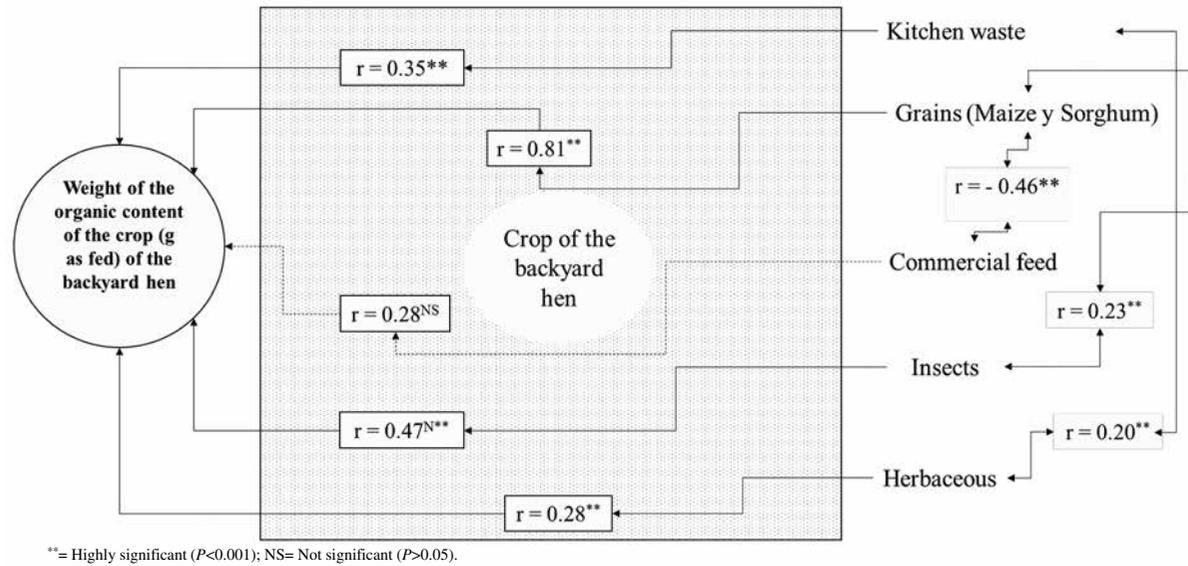
In TFS and NTFS, the BH complemented the diet with the picking of herbaceous and insects. The herbaceous content recovered from the crop was of 0.79 and 0.58 g DM for NTFS and TFS, respectively. Values that represented 3.0 and 3.1% of the OCC weight (table 1). Average weight of insect content was 0.88 and 0.26 g DM for NTFS and TFS respectively, averages were statistically different ( $P < 0.05$ ) and represented 3.4 and 1.4% of the OCC weight.

The correlations between the components of the diet and the weight of the OCC determined the following: the

grains (sorghum and maize) had the highest correlation with the weight of the OCC ( $r = 0.81$ ;  $P < 0.001$ ). The IS and KW components were correlated with the weight of OCC of 0.47 and 0.35 ( $P < 0.001$ ) respectively, whereas the COF component was not correlated with the weight of OCC ( $P > 0.05$ ) (figure 2). A positive correlation was observed between GS and IS ( $r = 0.23$ ;  $P < 0.001$ ), a negative between GS and COF ( $r = -0.46$ ;  $P < 0.001$ ) while a low association between KW and HS ( $r = 0.20$ ;  $P < 0.001$ ) (figure 2).

The chemical composition of the OCC showed that the nutritional composition of the diet during the rainy season was similar in both systems ( $P > 0.05$ ). The crude protein (CP) content was 12.2 and 12.4%, EE was 4.5 and 4.4% and CF was 18.6 and 18.3% for TFS and NTFS, respectively (table 2).

The average live weight (LW) of the BH (1.567 kg) was affected by the municipality and the feeding system ( $P < 0.001$ ). The average LW for NTFS (1.675 kg) and TFS (1.457 kg) were significantly different ( $P < 0.05$ ) from each other (table 3).



**Figure 2.** Pearson correlation coefficients between the components of the diet and the weight of the crop content of the backyard hens.

**Table 2.** Least squares means for the nutritional composition of the crop content (88% dry basis) of the hens according to the feeding system.

Variable	TFS	NTFS
	$\bar{x} \pm$	$\bar{x} \pm$
Dry matter (DM)	53.2 $\pm$ 9.6	51.6 $\pm$ 5.3
Ether extract (EE)	4.5 $\pm$ 2.7	4.4 $\pm$ 0.9
Crude Protein (CP)	12.2 $\pm$ 2.2	12.4 $\pm$ 1.7
Crude Fiber (CF)	18.6 $\pm$ 3.4	18.3 $\pm$ 1.8
Nitrogen free extract (NFE)	59.5 $\pm$ 4.7	57.7 $\pm$ 3.8

TFS = Traditional feeding system; NTFS = Non-traditional feeding system with the implementation of commercial feed.

The average for the EW of the BH was 51 g. The average EW was affected by municipality ( $P < 0.001$ ), but not by the feeding systems evaluated (table 3). The municipality with the greatest EW ( $P < 0.05$ ) was Numarán (57.0 g). Nevertheless, according to the municipalities evaluated, it was observed that the average EW of the BH ranged from 45.0 to 57.0 g; a difference of 12.0 g between the lightest and the heaviest egg (table 3). The lowest EW (45 g) was observed in the municipalities where less COF was found in the crops (table 1). In the municipalities where the TFS prevailed, the EW was greater ( $P < 0.05$ ) even when the LW of the BH of this municipalities was lowest (table 3).

## DISCUSSION

The feed content present in the crop of the BH is definitely key in the determination of not only the components of the diet, but also the nutritional composition because

in the family poultry production system it is difficult to establish the quantity and nutritional quality of the feed consumed by this type of fowl<sup>1,4</sup>. Therefore, to determine quantity and quality of the feed consumed by the BH it is necessary to obtain the feed directly from the crop, since the components of the diet are linked to the economic circumstances of the producer, the agro-ecological conditions of the region, the time of year and time of sampling<sup>4,5</sup>. In this sense, the TCW of the BH found during the rainy season (table 2) were superior to the reported values by Goromela *et al* (2008), Momoh *et al* (2010) and Rashid *et al*<sup>3</sup> who found TCW of 28.4, 29.8 and 15.2 g, respectively.

An important element for the TCW is its organic component. In agreement with current results, Goromela *et al* (2008) and Ruiz *et al*<sup>4</sup> found that cereal grains and kitchen waste are the major components of the OCC of the BH. Nonetheless, Momoh *et al* (2010) found that kitchen waste is the main component (37.9%) of the diet of BH, followed by maize and sorghum (23.3%), whereas the herbaceous and insects collected in the family backyard represented 9.2 and 7.9%, respectively. In this study, the OCC during the rainy season contained between 3.0 and 3.1% of insects (mainly R larvae) in the municipalities of Puruándiro and Santa Ana Maya, respectively. This result could be ascribable to municipalities having a vocation for the production of pigs and cattle (INEGI 2016). The manure produced by these species are favorable for incubation and nutrition of the larvae (Arango *et al* 2004).

On the other hand, the quantity and quality of the herbaceous and insects, which are a source of protein and energy useful for the fowl, are subject to the agro-ecological conditions of the rural communities<sup>5</sup>. According to Ponte *et al* (2008) and Huerta *et al* (2011), the consumption of herbaceous sources must not exceed 10% since an

**Table 3.** Least squares means for live weight and egg weight of the backyard hens (n=101) during the rainy season.

Municipality	Live weight (Kg)	Egg weight (g)
	$\bar{x} \pm$	$\bar{x} \pm$
System with the implementation of COF (NTFS)		
Santa Ana Maya	1.931 <sup>a</sup> ± 0.412	45.0 <sup>a</sup> ± 1.0
Cuitzeo	1.681 <sup>b</sup> ± 0.233	45.0 <sup>a</sup> ± 1.0
Coeneo	1.360 <sup>cd</sup> ± 0.209	45.0 <sup>a</sup> ± 2.0
Puruándiro	1.839 <sup>ab</sup> ± 0.319	50.0 <sup>b</sup> ± 1.0
Panindícuaro	1.666 <sup>b</sup> ± 0.148	50.0 <sup>b</sup> ± 1.0
Churintzio	1.541 <sup>bc</sup> ± 0.508	55.0 <sup>bc</sup> ± 1.0
Numarán	1.709 <sup>ab</sup> ± 0.227	57.0 <sup>c</sup> ± 2.0
$\bar{x} \pm$	1.675 <sup>1</sup> ± 0.187	49.0 <sup>1</sup> ± 4.0
Traditional feeding system (TFS)		
Zacapu	1.217 <sup>d</sup> ± 0.234	50.0 <sup>b</sup> ± 1.0
Ecuandureo	1.525 <sup>b</sup> ± 0.270	50.0 <sup>b</sup> ± 1.0
José Sixto Verduzco	1.633 <sup>b</sup> ± 0.337	50.0 <sup>b</sup> ± 2.0
Penjamillo	1.177 <sup>d</sup> ± 0.467	55.0 <sup>bc</sup> ± 1.0
La Piedad	1.521 <sup>bc</sup> ± 0.180	55.0 <sup>bc</sup> ± 1.0
Zináparo	1.721 <sup>ab</sup> ± 0.368	55.0 <sup>bc</sup> ± 1.0
Angamacutiro	1.364 <sup>cd</sup> ± 0.481	55.0 <sup>bc</sup> ± 1.0
Villa Jiménez	1.380 <sup>cd</sup> ± 0.173	55.0 <sup>bc</sup> ± 1.0
Huaniqueo	1.706 <sup>ab</sup> ± 0.165	50.0 <sup>b</sup> ± 2.0
Morelos	1.332 <sup>d</sup> ± 0.234	50.0 <sup>b</sup> ± 2.0
$\bar{x} \pm$	1.457 <sup>2</sup> ± 0.193	52.0 <sup>1</sup> ± 2.0

a, b, c, d = Different literals indicate differences ( $P < 0.05$ ) within the column.

1,2 = Different numerals indicate differences ( $P < 0.05$ ) between means within the column.

increase above 10% increases the amount of fiber, which can limit nutrient utilisation, feed efficiency resulting in reduced growth rate.

Thus, the results of this study suggest that during the rainy season BH feeding does not change, since it is continually based on the use of agricultural products (grains) and the kitchen waste of the rural families, and complemented by the consumption of forages, herbs and insects (Minh *et al* 2006, Mekonnen *et al* 2010).

Regarding the nutritional composition of the BH diet, Rashid *et al*<sup>3</sup>, Goromela *et al* (2008) and Momoh *et al* (2010) found CP contents of 10.2, 10.1 and 11.3%, respectively, percentages that are lower than the CP values (12.2-12.4%) in this study (table 2). Slightly higher CP values (12.9 and 15.5%) were reported by Mekonnen *et al* (2010). Even though in the present study the CP values were higher than the ones found by Rashid *et al*<sup>3</sup>, Goromela *et al* (2008) and Momoh *et al* (2010), the diets analysed are deficient in CP, considering that a CP reference point for laying hens should be between 16.5 to 17.5% (Mekonnen *et al* 2010, Momoh *et al* 2010). In addition, Juárez *et al* (2016) found evidence in the introduction of different genotypes, where genetically improved fowl does not necessarily improve productive indicators of the backyard system. For this

reason, the CP content of the diet should be close to the proposed by the NRC (1994) and Pérez (2013).

The COF could have played an important role in the CP percentage of the BH diet and was supplied by the housekeeper, in amounts (8.1 g on average per crop<sup>-1</sup> BH<sup>-1</sup>) that are not enough to observe an increment in CP except in the communities of Puruándiro and Panindícuaro, where the COF average in the crop of the BH was 17.1 and 16.2 g (table 1); or the COF was obtained by the BH in the pens of other animals (mainly pigs and cattle), and therefore the variability observed in the different systems analysed ranges from 1.4 to 17.1 g of COF in DM (table 1). This suggests that the NTFS was created circumstantially, given by the access of the BH to the COF in pens of other domestic animals (pigs or ruminants) present in the family plot.

Rashid *et al*<sup>3</sup>, Goromela *et al* (2008) and Momoh *et al* (2010) determined values for EE of 1.4, 5.4 and 5.1%, respectively. They also determined NFE, with values of 70.0, 54.6 and 49.0% respectively; 70.0% of NFE was superior to the determined in the analysed systems (57.5-59.5%). Regarding the CF of the diet, Momoh *et al* (2010) found 7.1% of CF, this percent was higher in comparison with the result obtained in this study (table 2), but higher to

the suggested by Blanco<sup>7</sup>: 5.0% of CF is sufficient in the diet of laying hens. But it is necessary to establish that the CF comes mainly from herbaceous sources, which are harvested by the fowl itself.

The LW of the BH observed during the rainy season could have been affected by genetics instead of the nutritional aspects (Martínez *et al* 2012, Martínez *et al* 2013), since the nutritional composition of both feeding systems (TFS and NTFS) were the same ( $P>0.05$ ). Juárez *et al*<sup>1</sup> reported a higher average LW of 1.750 kg for the BH compared to the low LW values of BH obtained in this study (table 3). Jerez *et al* (2009) reported similar weights between 1.4 and 1.7 kg, affected by the genetic group of the hens and the diet they received; this agrees with Galíndez *et al* (2012) and Lwelamira (2012), who reported that the weight of the hen is affected by genetic, climatic and zootechnical aspects.

The EW values found in this study are similar to those reported by Martínez *et al* (2012), who found EW of 51 g for BH fed a diet containing pumpkin seed flour. However, it has been reported<sup>1</sup> that the EW for the BH was of 55 g. A similar average EW of 55 g was observed in the municipalities of Penjamillo, Churintzio, Zináparo, Angamacutiro and Villa Jiménez (table 3). An inverse relationship was observed between the EW and LW of the BH ( $P<0.05$ ). This result is consistent with Martínez *et al* (2013), but in disagreement with Leeson and Summers (2005) who observed that EW increases with LW. Fuente *et al* (2012) and Pérez (2013) suggested that the EW is not only affected by the diet, but also by other factors such as genotype, age and week of posture of the hens.

According to the crop content of the BH during the rainy season, two feeding systems could be determined in the FPS analysed: the traditional system, in which the diet is based mainly on cereal grains (maize and sorghum) and kitchen waste, and complemented by insects and herbaceous sources; and the nontraditional feeding system, in which the same components as the TFS are found, plus the commercial feed.

The combination of these feed inputs in both FPS supplied the BH between 12.2 and 12.4% of CP to TFS and NTFS, respectively. The quantities of COF given or obtained circumstantially (in the pens of other domestic animals) were not sufficient to make a difference in CP from the TFS.

The LW and EW of the BH cannot be attributed to the diet during the rainy season. The variability in this indicators suggest that they are related to factors like genetics, age and rate of posture of this type of hens. A possible strategy to improve this systems involves to increase the levels of CP and EE, promoting the production of insects

within the family plot for the consumption of these by the BH all year round.

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