POTENTIALITIES OF THE *Cordia collococca* FRUIT FOR ITS USE IN THE FEEDING OF BIRDS

Potencialidades del fruto de *Cordia Collococca* para su uso en la alimentación de aves

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ABSTRACT. From Cuban´s provinces Pinar del Río is the most western, it is part of the second region of the country with endemic flora, it possesses great variety of arboreal species with multiple benefits for the agroecosystems, the contribution of its fruits for the animal feeding belongs one to them. In the agroecosistem, "El avioncito" belonging to Pinar del Río municipality exists a great readiness of the species *Cordia collococca*; the level of use of its fruits is very low. It was carried out a bromatological study in the research laboratory of the University of Pinar del Río and in the laboratory of the Institute of Animal Science, with the objective of knowing the qualitative and quantitative composition of the *Cordia collococca* fruit, their production and collection, to introduce the species in agroecological properties with the purpose of alternative alimentary for birds. The selection approach of the sample taking was carried out starting from the conditions of the plants, the soil type and the climatic conditions. The results of the bromatological study were obtained in two moments of fructification of the year 2013 and 2014. Similar percentages of gross protein were obtained to other species and vegetables used in the feeding of birds and data on the quantity of fruits that has a bunch and bunches that has a branch. A model represented by mathematical expressions to estimate the production of the fruit, statistical procedures are used to validate the proposed relationships.

Key words: feeding animal, estimation, evaluation

RESUMEN. De las provincias de Cuba, Pinar del Río es la más occidental, forma parte de la segunda región del país con flora endémica, posee gran variedad de especies arbóreas con múltiples beneficios para los agroecosistemas, el aporte de sus frutos para la alimentación animal es uno de ellos. En el agroecosistema "El avioncito" perteneciente al municipio Pinar del Río existe una gran disponibilidad de la especie Cordia *collococca*; el nivel de aprovechamiento de sus frutos es muy bajo. Se realizó un estudio bromatológico en el laboratorio de investigación de la Universidad de Pinar del Río y en el laboratorio del Instituto de Ciencia Animal, con el objetivo de conocer la composición cualitativa y cuantitativa del fruto de *Cordia collococca*, su producción y colección, para introducir la especie en fincas agroecológicas con la finalidad de alternativas alimentaria para aves. El criterio de selección de la toma de muestra se realizó a partir de las condiciones de las plantas, el tipo de suelo y las condiciones climáticas. Los resultados del estudio bromatológico se obtuvieron en dos momentos de fructificación de los años 2013 y 2014. Se obtuvieron porcentajes de proteína bruta similares a otras especies y vegetales utilizados en la alimentación de aves y datos sobre la cantidad de frutos que tenía un racimo y, los racimos que tenía una rama. Se propuso un modelo representado por expresiones matemáticas para estimar la producción del fruto, se utilizaron procedimientos estadísticos para validar las relaciones propuestas.

Palabras clave: alimentación animal, estimación, evaluación

INTRODUCTION

The contribution of traditional knowledge in the improvement of agricultural practices has proved its validity in recent years this has resulted in the emergence of new forms of research, linking scientific knowledge with local knowledge (1). Cuban forests are not characterized by many species with fruits or edible parts; however, since past centuries, farmers used the fruit of the species *Cordia collococca* to feed birds and pigs (2).

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Its fruits are desired by the birds (3). The participatory rural survey (4), the participatory plant breeding (5) and the management of local innovation processes (6-8), measure the degree of importance of the species and the weighting of the values of their dominances, abundances, frequencies, besides contributing knowledge to the ecological theory. Through the measurement of the relative abundance of the species, it can be identified if the species, due to its low representativeness in the community, is sensitive to environmental disturbances.

A greater diversity, ecological stability and productivity (9), greater resistance to the invasion of exotic species, therefore, introduce species into agroecosystems that have past cultures with economic use, regenerate the system components (soil-animal-climate-man) (10). Within the animal component, the species of birds benefit from the methods of organic farming, their management is simple and the products obtained from them are of high nutritional quality and low cost (11).

The birds have a double purpose, because they are used for human food providing egg and meat, being an important source of protein in the family diet, they are also soil renewers and help control some plant pests. Almost all the natural species that have been studied comparatively in ecological and conventional farms show a greater population and variety in ecological than in conventional ones (12).

On the other hand, obtaining products and raw material for different industrial activities (13) has now become a major task. The elaboration of feed from the *Cordia collococca* fruit is articulated around the agroindustrial complex with the system's own resources from savings by import substitution, besides taking advantage of the protective functions of the tree, achieving the increase of food production to over time and improve the immediate microclimate conditions, through the shadow projected by their tops (14).

As an unused crop in the country, the study of the potential of the fruits represents an invaluable tool in the promotion and search of efficient and effective alternatives for animal feed, because it is an abundant food that does not compete with the human diet,

therefore, the bromatological study and the estimation of the *Cordia collococca* fruit production provides a tool of utilities for decision making, since there are no references on this study.

MATERIALS AND METHODS

GEOGRAPHICAL LOCATION OF THE STUDY AREA

The present investigation was carried out in the agroecosystem "El Avioncito", belonging to the Pinar del Río municipality in October 2013 and May 2014 (Figure 1).

It limits to the North with the Biofactory, to the south with the Pinar del Río-Habana highway, to the east with the entrance to the "Hermanos Cruz" town from the Pinar del Río-Habana highway and to the west with the old Borrego aircraft track.

Figure 1. Location "El Avioncito"

EDAPHOCLIMATIC CHARACTERISTICS OF THE AGROECOSYSTEM

The area under study covers a total area of 1,5 ha, the predominant soil is the Acrisol Chromic Ferric type (15). The topography of the place is predominantly flat, with some undulations in certain specific places of the place (Table I).

According to investigations (15), this genetic type of soils presents the following characteristics in its main diagnostic horizon (Ferralitic).

Table I. Type of predominant soil in the studied area. Correlation with other soil classifications at an international level

Genetic type (IS, 1975)	Total area (ha)	New version (Hdez *et al.,* 1999)	Soil Taxonomy (USDA, 2003)	World Reference Base
Ferralitic quartzitic yellow leachate (FCAL)	1,5	Yellowed ferralitic leachate	Plinthustalf	Acrisol Chromic – Ferric

Subsurface horizon characterized by:

♦ Predominance of clayey minerals of type 1: 1, which can reach up to 10 % of type 2: 1 of the total content of the clayey fraction.

♦ Cation exchange capacity <20 cmol (+) Kg^{-1} in clay

♦ SiO_2 ratio: Al_2O_3 less than 2,3 in clay.

♦ Alterable mineral content less than 10 % of the fraction between 20 and 200 micros

♦ Content less than 60 % of iron sesquioxides in the fraction <2 micros

♦ Structure with fine or very fine aggregates, rounded micro aggregates

To analyze the behavior of climatic variables at the site, the mean values of temperature and rainfall for the period 2013-2014, belonging to the meteorological station "Pinar del Río" were taken.

To carry out the bromatological analysis, fresh fruit samples of *Cordia collococca* were taken, they were collected in two fruiting periods (October 2013 and May 2014), the latter coinciding with the period of greatest fruiting of the species in the year. The study area was divided into three lots (left, center and right), the conditions of the plants, the type of soil and the climatic conditions are the variables that were taken into account for the selection criteria of the sample. Finally, 4 plants were selected at random from each one of them the fruits were taken (Photo 1) for a total of 900 fruits. Of them 120 fruits were taken, they were pulped and said pulp was weighed obtaining 97,6768 g.

For the bromatological study, the following methods were assumed:

♦ Determination of proteins: micro-kjeldhal method.

♦ Determination of crude fiber: gravimetric method.

♦ Calcium determination: metric complex titration method with EDTA.

♦ Dry mass, phosphorus and ashes: According to the standards described (16).

♦ Vitamin C by the volumetric method

Periodic observations were made and two reproductive periods of fruiting were determined during the year. The chemical analysis was made from the taking of samples corresponding to the month of October 2013 and May 2014.

To estimate the fruit production of *Cordia collococca*, reference was made to what was proposed by Rendón *et al*. (17). According to visual appreciation, the quantities of fruits were recorded, the fruits were counted; the number of small branches, the number of bunches that the small branches have and the number of fruits present in a cluster was taken into account (Photo 2).

Photo 2. Branches with fruits of *Cordia collococca*

The simple random method was applied and a sample of eight trees was taken according to criteria of representativeness. A ladder was used for the collection, the weight of the fruits ranged between 0,9989 and 1,2902 g. 19 L cuvettes were used for the collection, they were filled and the weight ranged between 16 and 18 kg, the estimation errors were determined from the estimated structure described by the simple random method, levels ranging between 0,50 were assumed and 0,85 % given the variability of the crops, a series of mathematical expressions were defined from the data.

Photo 1. Cluster of fresh fruits of *Cordia collococca*

Proportion of trees with fruits (1)

$$PAFr = \left(\frac{NAFr}{n} \right) * 100$$

PAFr= Proportion of trees with fruits
N=Size of smple
NAFr= Number of trees with fruits

Total of fruits: (2,4)

$$PFr = \sum_{x=1}^{10} \frac{ax}{10} \quad PRgr = \sum_{x=1}^{10} \frac{bx}{10} \quad Pgr = \sum_{x=1}^{10} \frac{cx}{10}$$

$$TFy = PFr * PRgr * Pgr$$

PFr= Proportion of trees with fruits in the evaluation
ax= Number of minor branches with bunches
PRgr= Average of minor branches with bunches in the evaluation.
bx= Number of bunches with fruits
Pgr= Average of bunches with fruits in the evaluation
cx= Number of fruits in the bunches

Fruit of percentage: (5)

$$PTFrj = \frac{TFry}{\sum_{y=1}^{m} Fry} * 100$$

PTFrj= Percentage of fruits in evaluation and
TFry= Total of fruits in the evaluation area
m=Number of evaluations in each period

Amount of fruits to be collected: (6,7)

$$TFCrg = \left(\sum_{v=1}^{m} TFry \right) * 0,50 * 1,2 \quad TFrc = \left(\sum_{v=1}^{m} Fry \right) * 0,85 * 1,22$$

TFrc=Quantity of frutis to harvest in grames
TFCrg= Total of fruits to gather in a harvest
TFry= Total of fruits in the evaluation area
m=number of evaluations in each period

Data processing was carried out with the statistical package STATGRAPHICS® (18), for Windows®.

To estimate the number of fruits, the linear analysis was used, with the multiple linear regression procedure to see in what measure the dependent variable (PTFr) can be explained by the independent variables (PRgr and Pgr) proposed in the system of mathematical expressions and obtain predictions needed. To validate the model, the conditions of the statistical assumption were taken into account. These conditions are given by linearity, independence, normality, homocedasticity and collinearity (19-21).

RESULTS AND DISCUSSION

The results of the chemical analysis by year and fruit fruiting stages of the *Cordia collococca* species are summarized in Table II.

The standard deviation gives us the result precision of the sample (22,23), it tells us if the mean of the measurements is too far from the prediction. We cannot consider that the measures contradict this theory, since it is the first time that this bromatological study is carried out for the fruit of the species *Cordia collococca* (Table III).

There are no significant statistical differences in the results of the studies conducted despite taking samples of fruits in different years and times of fruiting, coinciding with the conditions of the plants (healthy), soil (deep), maximum temperatures between the months of June and October with values ranging between 29,8-30,6 ºC and a wide rainy period in the months of January, May and October, very rainy in June and September with rainfall exceeding 100 mm.

The values of dry matter are low in the two evaluations, which mean that they have high moisture contents. For this reason, it must be taken into account that when these fruits are used to form part of a mixture, they must have approximately 85 % dry matter, after dehydration by drying in the sun. Only in this way, that is, dehydrated and ground can they be considered fit to be part of any formulation (24).

Table II. Results of the bromatological study of *Cordia collococca* fruit

%	Year 2013 (October) ICA	Year 2014 (May) UPR
M.S	20,23	31,27
Ceniza	4,95	5,78
Ca	0,96	0,96
P	0,19	0,21
Mg	0,38	0,38
K	1,38	1,39
PB	14,26	15,81
FB	21,81	22,90
Vit C	------	2 mg*

2 mg* Ascorbic acid in 30 mL of fruit drink *Cordia collococca* MS (Dry matter), Ca (Calcium), P (Phosphorus), Mg (Magnesium), K (Potassium), PB (Crude Protein), FB (Gross Fiber), Vitamin C

Table III. Statistical results of the bromatological study of Cordia collococca fruit

	Dry mass	Ashes	Calcium	Phosphorus	Potassium	Crude protein	Crude fiber
Mean	25,7500	5,3650	,9600	,2000	1,3850	15,0350	22,3550
N	2	2	2	2	2	2	2
Typical deviation	7,80646	,58690	,00000	,01414	,00707	1,09602	,77075

The average crude protein and crude fiber percentages are higher than other forage plants (25), considering the fruit of the species with potential for food alternatives for birds, taking into account their nutritional requirements; however, these values are lower than the percentages of grasses in general (26). On the other hand in the percentages of calcium, potassium and phosphorus there are no significant differences considered low, according to the values of Vitamin C are low, although it is noteworthy that this vitamin is only essential in a few animals.

Table IV shows examples of the dry mass percentages (MS), crude protein (PB), crude fiber (FB), carbon (C), calcium (Ca) and phosphorus (P) of different foods and food alternatives used In different agroecosystems for feeding birds, they can be compared with the fruit of *Cordia collococca*.

The Table shows how PB values of the *Cordia collococca* fruit exceeds the values of corn bran and rice polishing, foods frequently used in the feeding of birds, in addition the similarity of the values of PB that can be observed with the food alternatives of FHIA-18 banana foliage supplement and breadfruit tree flour, therefore, the crude protein evaluated is considered within the limits that defines an arboreal species as a forage potential, since it exceeds 8 % crude protein (27).

The statistics are used in the investigation to justify the proposed expressions, in which the most appropriate analysis procedures are applied (27). The results of these analyzes can be explained through the graphs of Figure 2. It can see the linear relationship between the Dependent Variable (VD): percentages of fruits under evaluation (PTFr) and independent variables (VI) (Average of smaller branches with clusters in the evaluation (PRgr) and average of clusters with fruits (Pgr).

At first sight there seems to be a positive relationship between the RV and the VI. It can be seen that the dispersion diagram is linear, as VD increases VI increases, this is considered but not very specific. To obtain a correct description of the production estimate of the *Cordia collococca* fruit, the specific data that are available from the selected samples are listed and a straight line is obtained, this can be a good starting point to describe the amount of fruits which is obtained from the number of branches with bunches available to a tree and the amount of fruit that has a cluster of *Cordia collococca* fruits.

On the other hand, there are a series of conditions that must exist to guarantee the validity of the model, the assumptions inform the accuracy degree of the forecasts, the analysis of independence, normality and homoscedasticity are the conditions from the diagnosis of the residues (Table V).

Table IV. Comparison of the bromatological values of Cordia collococca fruit with other food sources

	MS	PB	FB	Ash	Calcium	Phosphorus
Bran of corn (23)	86,0	9,9	9,5	3,0	-----	------
Rice polydure (23)	87,5	12,5	12,0	5,0	-----	-----
Fresh fruit of Cordia collococca	23,62	14,9	22,9	5,3	0,96	0,19
Supplement of banana foliage variety FHIA-18 (23)	21,10	14,3	48,7	10,7	0,02	0,01
Breadfruit flour (26)	89,64	13,35	11,15	----	0,77	0,15
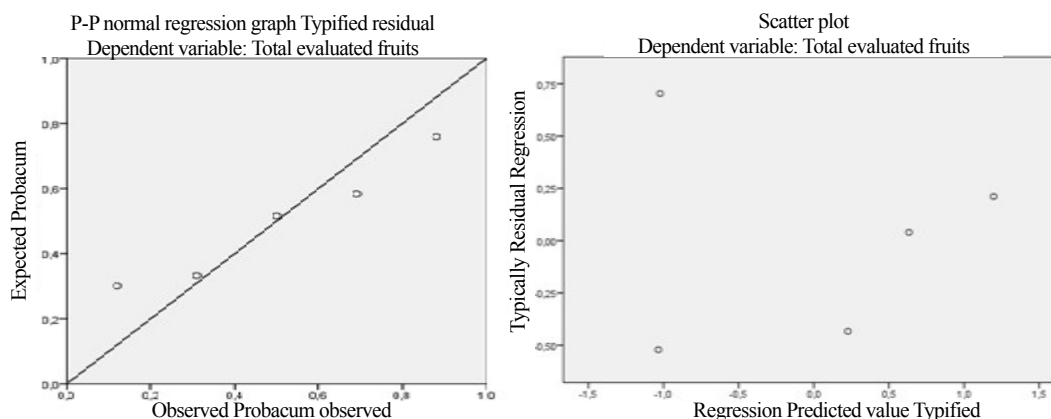
Figure 2. Representation of the net relation between the VD (PFTr) and the VI (PRgr and Pgr)

Table V. Diagnosis by case residue

Number of cases	Typical residues	Total of evaluated fruits	Predicted value	Residual
1	-0,521	1,000	1,480	-0,41798
2	0,703	2,000	1,4362	0,56385
3	-0,433	3,000	3,3471	-0,34714
4	0,040	4,000	3,9682	0,03180
5	0,211	5,000	4,8305	0,16948

a. dependent variable: Total evaluated fruits

It can be observed that the result of the behavior of the waste is small, the forecast of the relationship that exists between the RV and the VI is correct so that the percentage of the total of fruits can be determined by the proposed model.

Therefore, the standard deviation expressed as a percentage of the arithmetic mean (28,29) makes a dimensionless coefficient, invariant by the scale of measurement of the variables analyzed (Table VI).

Table VII shows the information corresponding to the independence that exists between the wastes. The analysis of the temporary data presented a negative autocorrelation taking values of three, this value are within the values established by this assumption, ratifying the validity of the proposed model.
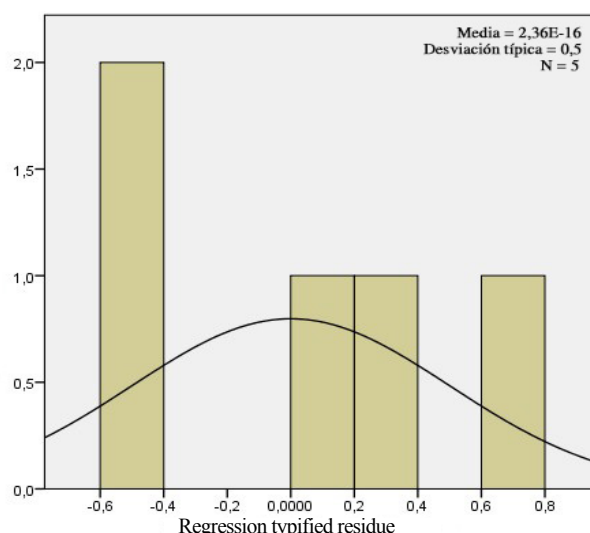
For the analysis of normality in (Figure 3) a graph with a histogram of normal residuals with a normal overlapped curve is presented. The curve is constructed taking an average of 2,3 and a standard deviation of 0,5; that is, the same mean and standard deviation of the typified waste.

In the histogram of the normal residuals it is observed that the distribution is somewhat asymmetric. In the positive tail of the distribution there are more extreme values than in the negative tail, it does not seem to follow the normal probability model so the results of the analysis should be interpreted with caution, this is the reason for assuming levels between 0,50 and 0,855 % given the variability of bunches in the branches and number of fruits in the bunches.

Table VIII shows the solution resulting from applying an analysis of the main components to the standardized matrix not centered of cross products of the independent variables.

The diagnosis was an appropriate statistical tool for the analysis of the RV and VI (30), as has been demonstrated in other studies (31).

The presence of several eigenvalues close to zero indicate that the independent variables are very related to each other, in terms of the condition indices, they do not exceed the values of 15, so they do not indicate problems of relations between the independent variables proposed in the model, for the estimation of the fruit production of *Cordia collococca*. For subsequent studies, the sample number must be greater to avoid errors in non-collinearity conditions.

Table VI. Mean and standard deviation of waste

	Minimum	Maximun	Typical deviation	N
Predicted value	1,4180	1,8305	1,52917	5
Residual	-0,41798	0,56385	0,40090	5
Typical predicted value xc	1,034	1,197	1,000	5
Typical residue	-0,521	0,703	0,500	5

Table VII. Additional information about the DW statistic

		Summary of the model		
R	R squared	R squared corrected	Standard error of the estimate	Durbin-Wats
,967	,936	,743	,80179	3,043

a. Predictive variables: (Constant), Pgr, PFr, PRgr
b. Variable pending: Total evaluated fruits

Figure 3. Histogram of normal waste

Table VIII. Collinearity diagnostics

Dimension	Eigenvalues	Condition index	Proportions of variance			
			Constant	PFr	PRgr	Pgr
1	3,833	1,000	0,00	0,00	0,00	0,00
2	0,099	6,254	0,01	0,07	0,07	0,00
3	0,0015	15,910	0,00	0,92	0,88	0,98

CONCLUSIONS

♦ Crude protein percentages similar to other species and vegetables used in poultry feeding are obtained.
♦ The proposed model is a very useful tool to estimate the production of *Cordia collococca* fruits.
♦ The determination coefficient of the quality of the regression equation and the fulfillment of the assumptions were estimated to guarantee the validity of the procedure used in the model.

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