The Effects of Waste Contaminated Soil on the Productive Capacity of *Capsicum frutescens*

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ABSTRACT

The effects of waste contaminated soil on the growth and yield of *Capsicum frutescens* was studied. Soil samples were collected from: (1) chemical dump sites (2) Cocoa Processing Locations, (3) Federal University of Technology, Akure (FUTA) farms (i.e. Obanla, Obaekere and Abaoyo), and (4) a fallow field (control) all within Akure metropolis. The electrical conductivity and pH of the different soils were determined using standard methods while heavy metal analysis of the various soil samples was carried out using Buck 200 Atomic Absorption Spectrophotometer (ASS) after digesting the samples. The length of stem and leaves were recorded. Soil samples obtained from all the cocoa processing locations and chemical dumpsites in Akure metropolis showed no growth. Meanwhile, the control showed growth of *C. frutescens*. The highest height of stem was in Obanla on day 29 (15.92 ± 0.82 cm) while that of leaf (4.06 ± 1.32 cm) was in Obaekere on the same day. The control had higher mean stem height of 24.67 ± 1.32 cm on day 29 and 6.17 ± 0.17 cm for leaf on same day. Although, relatively higher organic matter was recorded in FUTA area with Obaekere having the least of $4.26 \pm 0.06\%$ and Abaoyo having the highest of $4.36 \pm 0.06\%$, this was lower than the control which had $4.50 \pm 0.12\%$. Generally, the heavy metals concentration was higher in the cocoa processing locations and chemical dumpsites, as compared to FUTA area and the control. The low organic matter and heavy metal concentration in the soils cannot guarantee food security in terms of intensive crop production.

Keywords: *Capsicum*, Growth, heavy metal, soil.

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I. INTRODUCTION

The soil is usually at the receiving end of improperly-disposed wastes including heavy metals which needs to be treated [1]. Its contaminations results in poor crop growth for months or several years depending on the degree of contamination [2]. Pepper is an important agricultural crop not only because of its economic importance [3]. Nigeria is known to be one of the major producers of pepper in the world accounting for about 50% of the African production and the major area of production is Northern Nigeria [4]. Crop production involves a complex interaction between the environment, soil physico-chemical parameters and nutrient dynamics. Failure to understand these complexities has resulted in lack of good crop production and management techniques; hence low agricultural production. Understanding the relationship between plant growth and soil physico-chemical properties could act as a guide to help farmers understand the likely soil conditions that could be suitable for a growth of *C. frutescens*. This study therefore investigated the effect of waste contaminated soils on the growth and yield of *C. frutescens*.

II. MATERIALS AND METHODS

A. Soil Collection and Processing

Soil samples were randomly collected from three locations each in chemical dump sites of Ondo State Waste Management Authority, Cocoa Processing Limited, and Federal University of Technology, Akure (FUTA) farm, all within Akure Metropolis. The specific locations of the chemical dumpsites were Oda, Fiwasaye and Igbatoro, while those of the Cocoa Processing Limited were COOP cocoa production; Alaranse cocoa processing unit and Ile Oluji cocoa production unit. In FUTA, the samples were collected from Abaoyo, Obaekere and Obanla. The soil samples were dried to constant weight in an oven and sieved to remove large particles and debris. The soil was screened through 2mm stainless sieve before being transferred into experimental pots.

B. Planting of Seeds and Germination Studies

Seeds of *Capsicum frutescens* were obtained from Agricultural Development Project (ADP), Akure, Ondo State. Four seeds of *Capsicum frutescens* were planted in each of the experimental pots. The pots were arranged in Completely Randomized Design within the experimental screen house. The soil sample obtained from FUTA fallow farm served as control. Growth parameters including

number of leaves and height of stems were taken after two week and thereafter at one week interval for a month.

C. Determination of Physico-chemical parameters pH and electrical conductivity

20ml of distilled water was added to 10g of air-dried, sieved soil (2mm), stirred and allowed to stand for 30minutes with occasional stirring. The electrical conductivity of the slurry was measured using EC meter (Model 470) and reported in $\mu\text{S}/\text{cm}$. 5g of each soil sample was mixed with 5ml of distilled water, stirred and allowed to stand for 30minutes.

D. Organic Matter Determination

Organic matter was determined by Walkley-Black wet oxidation method [5] while organic nitrogen was determined by Kjeldahl method.

E. Determination of Heavy Metals

The soil samples were dried in the laboratory oven at 60°C for three days to obtain a constant dry weight and digested using HNO_3 . Buck 200 Atomic Absorption Spectrophotometer (ASS) was used for the determination of the heavy metals in triplicate.

F. Statistical Analysis

The data obtained were subjected to analysis of variance (ANOVA) at $P < 0.05$ and the means were separated using Duncan's Multiple Range Test.

III. RESULTS

A. Physio-chemical Parameters of Soil Samples

The physico-chemical parameters of soil samples are presented in Table 1. Significantly higher ($P < 0.05$) percentage of organic carbon (%OC) (2.56 ± 0.03), organic matter (%OM) (4.50 ± 0.12) and Organic nitrogen (%ON) (0.35 ± 0.01) were obtained in the control soil when compared to those obtained from Oda, Fiwasaye and Igbatoro dumpsites respectively. Organic carbon (%OC) (2.47 ± 0.03) and organic matter (%OM) (4.26 ± 0.06) recorded at Obakekere was significantly lower ($P < 0.05$) than that of Obanla, Abaoyo and control soil respectively (Table 2). The Percentage organic carbon (%OC) of the three sub-locations were significantly different ($P < 0.05$) from the control (2.56 ± 0.03). Ile-Oluji cocoa processing unit (ICP) recorded the highest %OC of 2.47 ± 0.01 which was not significantly different from 2.45 ± 0.12 recorded at Alaranse cocoa processing unit (ACP) (Table 3). Although the Electrical Conductivity recorded at ICP ($0.17 \pm 0.01 \mu\text{S}/\text{cm}$) showed no significant difference ($P > 0.05$) from the control, it was significantly different ($P < 0.05$) from CCP ($0.28 \pm 0.00 \mu\text{S}/\text{cm}$) and ACP ($0.23 \pm 0.00 \mu\text{S}/\text{cm}$).

B. Heavy metals in soil samples

The concentration of heavy metals in the soil samples varied with the locations Table 4. The concentrations of Zn, Cd, Mn, Fe and Cu in the control soil were significantly lower ($P < 0.05$) than those observed in the soil samples obtained from each dumpsites. Also, highest concentration of Zn ($14.60 \pm 0.06 \text{ mg}/\text{kg}$) and Cr ($4.00 \pm 0.51 \text{ mg}/\text{kg}$) were not significantly different from that of soil samples obtained from Oda and Fiwasaye dumpsites respectively. The concentration of heavy metals in soil samples obtained from farms in FUTA area (Abaoyo, Obakekere and Obanla) is given in Table 5. The levels of Zn, Cr, Mn, Fe and Pb in

the control soil were significantly lower ($P < 0.05$) than that observed in soils from farms in FUTA area. The concentration of heavy metals in soil samples obtained from the cocoa processing locations is shown in Table 6. The level of each heavy metal in the control soil was significantly lower ($P < 0.05$) than that observed in soil samples of COOP cocoa production (CCP), Alanrase Cocoa Processing unit (ACP) and Ile-oluji cocoa production unit (ICP). The highest concentration of zinc ($17.00 \pm 0.60 \text{ mg}/\text{kg}$) in ICP was not significantly higher ($P > 0.05$) than $16.40 \pm 0.60 \text{ mg}/\text{kg}$ and $16.00 \pm 0.60 \text{ mg}/\text{kg}$ of ACP and CCP soil samples respectively.

C. Growth Performance of Stem and Length of *C. frutescens* on Different Soil Samples

Table 7 and 8 shows the mean length of stems and leaves of *C. frutescens* cultivated on soil samples obtained from different locations respectively. Generally, the mean length of *C. frutescens* stem and leaves cultivated on FUTA fallow land (control) was significantly higher ($P < 0.05$) than those cultivated on other locations. Similarly, the length of stem and leaves increased with increasing days. Highest Stem ($24.67 \pm 1.32 \text{ cm}$) and leaf length ($6.17 \pm 0.17 \text{ cm}$) were also observed in the control soil sample (Tables 7 and 8).

IV. DISCUSSION

The percentage organic matter (%OM) of the soil samples of chemical dumpsites was much lower than those of FUTA area, and the control. Also, the heavy metal concentration in the chemical dumpsite and cocoa processing locations were higher than FUTA area and the control. This explains why soil samples obtained from all the cocoa processing locations as well as the dumpsites in Akure metropolis did not support the growth of *Capsicum frutescens*, while the control and soil samples of FUTA area did. The Organic nitrogen, electrical conductivity was generally lower than the recommended limit of 0.20% and $4 \mu\text{S}/\text{cm}$, respectively. The high phosphate levels of the cocoa processing locations obtained as earlier been reported [6] in which phosphate was a major waste in cocoa production and processing. The higher concentration of heavy metals in the soil of each locations control can be attributed to pesticide residues in the dump sites, cocoa processing locations and FUTA farms.

V. CONCLUSION

The heavy metal status of the soils is within the permissible limits [7]. However, the higher concentration of chromium in soil samples of the dumpsites and cocoa processing location coupled with low organic matter and high phosphate values inhibited the growth of *Capsicum frutescens*, as compared to soil samples of farms of FUTA area and the control (fallow) which supported its growth. It is therefore recommended that there should be periodic environmental auditing and monitoring of the project in industrial area to ensure environmental quality and sustainability. Also, proper disposal of wastes within Akure metropolis is advocated.

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TABLE 1: PHYSICOCHEMICAL PARAMETERS OF SOIL SAMPLES COLLECTED FROM DUMPSITES ACROSS AKURE METROPOLIS

Dumpsite	%OC	%OM	%ON	P (mg/kg)	pH	EC (µS/cm)
Oda	1.51±0.06 ^c	2.61±0.06 ^c	0.08±0.02 ^b	49.18±0.06 ^c	8.93±0.33 ^a	0.07±0.03 ^{ab}
Fiwasaye	1.20±0.03 ^b	2.08±0.06 ^b	0.06±0.01 ^{ab}	28.52±0.08 ^a	8.93±0.67 ^a	0.07±0.03 ^{ab}
Igbatoro	1.07±0.06 ^a	1.85±0.03 ^a	0.05±0.01 ^a	63.93±0.01 ^d	8.97±0.33 ^a	0.07±0.00 ^{ab}
Control soil	2.56±0.03 ^d	4.50±0.12 ^d	0.35±0.01 ^c	35.13±0.09 ^b	8.91±0.05 ^a	0.05±0.01 ^a
FEPA limit	2.0	>3.4	0.20	20	4.8-9.5	4

%OC = Percentage organic carbon; %OM = Percentage organic matter; %ON = Percentage organic nitrogen; EC = Electrical conductivity; Control soil = Soil from FUTA fallow land. Results of the mean of three triplicate results ± standard error of mean. Values of the same superscripts down the column are significantly different at $P < 0.05$ using Duncan Multiple Range Test.

TABLE 2: PHYSICOCHEMICAL PARAMETERS OF SOIL SAMPLES OBTAINED FROM FARMS IN FUTA AREA

Location	%OC	%OM	%ON	P(mg/kg)	pH	EC (µS/cm)
Abaoyo	2.53±0.06 ^c	4.36±0.06 ^c	0.13±0.02 ^a	70.82±0.06 ^c	8.97±0.03 ^a	0.06±0.01 ^a
Obakekere	2.47±0.03 ^a	4.26±0.06 ^a	0.12±0.03 ^a	41.31±0.02 ^{ab}	8.87±0.01 ^a	0.11±0.01 ^b
Obanla	2.49±0.06 ^b	4.29±0.12 ^b	0.12±0.00 ^a	162.30±0.01 ^d	8.93±0.07 ^a	0.06±0.02 ^a
Control soil	2.56±0.03 ^d	4.50±0.12 ^d	0.35±0.01 ^b	35.13±0.09 ^a	8.91±0.05 ^a	0.05±0.01 ^a
FEPA limit	2.0	>3.4	0.20	20	4.8-9.5	4

CCP = COOP cocoa production; ACP = Alaranse cocoa processing unit; ICP = Ile Oluji cocoa production unit; %OC = Percentage organic carbon; %OM = Percentage organic matter; %ON = Percentage organic nitrogen; EC = Electrical conductivity; Control soil = Soil from FUTA fallow land. Results of the mean of three triplicate results ± standard error of mean. Values of the same superscripts down the column are not significantly different at $P < 0.05$.

TABLE 3: PHYSICOCHEMICAL PARAMETERS OF SOIL SAMPLES OBTAINED FROM COCOA PROCESSING LOCATIONS

Location	%OC	%OM	%ON	P (mg/kg)	pH	EC
CCP	2.41±0.02 ^a	4.16±0.02 ^a	0.12±0.01 ^a	708.20±0.06 ^b	9.00±0.01 ^a	0.28±0.00 ^c
ACP	2.45±0.12 ^b	4.23±0.06 ^b	0.12±0.00 ^a	884.26±0.06 ^b	9.03±0.01 ^a	0.23±0.00 ^b
ICP	2.47±0.01 ^b	4.26±0.01 ^c	0.12±0.01 ^a	897.04±0.02 ^c	9.03±0.07 ^a	0.17±0.01 ^a
Control soil	2.56±0.03 ^c	4.50±0.12 ^d	0.35±0.01 ^b	35.13±0.09 ^a	8.91±0.05 ^a	0.05±0.01 ^a
FEPA limit	2.0	>3.4	0.20	20	4.8-9.5	4

CCP = COOP cocoa production; ACP = Alaranse cocoa processing unit; ICP = Ile Oluji cocoa production unit; %OC = Percentage organic carbon; %OM = Percentage organic matter; %ON = Percentage organic nitrogen; EC = Electrical conductivity; Control soil = Soil from FUTA fallow land. Results of the mean of three triplicate results ± standard error of mean. Values of different superscripts within the row are significantly different at $P < 0.05$.

TABLE 4: MEAN CONCENTRATION OF HEAVY METALS (MG/KG) IN SOIL SAMPLES COLLECTED FROM DUMPSITES ACROSS AKURE METROPOLIS

Dumpsites	Zinc	Cadmium	Chromium	Manganese	Iron	Copper	Lead	Nickel
Oda	13.60±0.06 ^b	0.20±0.06 ^b	3.00±0.58 ^a	7.20±0.51 ^b	510.00±0.51 ^c	5.20±0.95 ^d	6.00±0.58 ^b	1.20±0.12 ^a
Fiwasaye	14.00±0.58 ^b	0.20±0.00 ^b	3.60±0.58 ^a	8.00±0.58 ^b	602.00±0.51 ^d	4.20±0.12 ^b	8.00±0.06 ^c	1.80±0.11 ^b
Igbatoro	14.60±0.06 ^b	0.20±0.12 ^b	4.00±0.51 ^a	7.60±0.55 ^b	432.00±0.23 ^b	4.80±0.10 ^c	4.00±0.55 ^a	1.60±0.06 ^b
Control soil	9.05±0.17 ^a	0.01±0.00 ^a	3.12±0.00 ^a	5.50±0.31 ^a	400.00±0.98 ^a	3.69±0.32 ^a	3.47±0.01 ^a	1.13±0.02 ^a
FEPA limits	300	10	100	2000	10000	100	70	1000

Means followed by the same letter in the same column are not significantly at $P < 0.05$ (Duncan's Multiple Range Test).

TABLE 5: MEAN CONCENTRATION OF HEAVY METALS (MG/KG) IN SOIL SAMPLES COLLECTED FROM FARMS IN FUTA AREA

Farm	Zinc	Cadmium	Chromium	Manganese	Iron	Copper	Lead	Nickel
Abaoyo	11.20±0.12 ^c	0.40±0.06 ^b	3.60±0.06 ^b	5.60±0.12 ^a	412.00±0.21 ^c	3.60±0.02 ^a	4.00±0.06 ^b	1.00±0.29 ^a
Obakekere	10.40±0.06 ^b	0.40±0.02 ^b	4.00±0.01 ^c	6.20±0.06 ^b	421.00±0.32 ^d	4.00±0.12 ^b	6.00±0.12 ^c	1.20±0.00 ^a
Obanla	11.60±0.00 ^d	0.02±0.00 ^a	3.60±0.12 ^b	6.40±0.01 ^b	407.00±0.52 ^b	4.40±0.20 ^c	4.00±0.17 ^b	1.20±0.06 ^a
Control soil	9.05±0.17 ^a	0.01±0.00 ^a	3.12±0.00 ^a	5.50±0.31 ^a	400.00±0.98 ^a	3.69±0.32 ^a	3.47±0.01 ^a	1.13±0.02 ^a
FEPA limits	300	10	100	2000	10000	100	70	1000

Means followed by the same letter in the same column are not significantly at $P < 0.05$ (Duncan's Multiple Range Test).

TABLE 6: MEAN CONCENTRATION OF HEAVY METALS (MG/KG) IN SOIL SAMPLES COLLECTED FROM COCOA PROCESSING LOCATIONS

CCP = COOP cocoa production; ACP = Alaranse cocoa processing unit; ICP = Ile Oluji cocoa production unit. Means followed by the same letter in the

Location	Zinc	Cadmium	Chromium	Manganese	Iron	Copper	Lead	Nickel
CCP	16.00±0.60 ^b	0.60±0.06 ^b	4.20±0.06 ^a	8.80±0.03 ^b	870.00±0.58 ^b	6.40±0.06 ^b	12.00±0.06 ^b	2.20±0.06 ^c
ACP	16.40±0.60 ^b	0.60±0.00 ^b	4.60±0.02 ^c	9.20±0.12 ^b	1000.00±0.51 ^d	7.20±0.02 ^c	10.00±2.31 ^b	2.40±0.00 ^d
ICP	17.00±0.60 ^b	0.80±0.12 ^b	4.40±0.01 ^b	9.00±0.12 ^b	994.00±2.31 ^c	7.60±0.06 ^d	12.00±0.06 ^b	1.80±0.06 ^b
Control soil	9.05±0.17 ^a	0.01±0.00 ^a	3.12±0.00 ^a	5.50±0.31 ^a	400.00±0.98 ^a	3.69±0.32 ^a	3.47±0.01 ^a	1.13±0.02 ^a
FEPA limits	300	10	100	2000	10000	100	70	1000

same column are not significantly at $P < 0.05$ (Duncan's Multiple Range Test).

TABLE 7: HEIGHT OF CAPSICUM FRUTESCENS STEM (CM) CULTIVATED ON SOIL SAMPLES COLLECTED FROM DIFFERENT LOCATION

Location	Age (Days)						
	17	19	21	23	25	27	29
Oda	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
Fiwasaye	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
Igbatoro	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
CCP	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
ACP	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
ICP	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
Abaoyo	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	5.22 ± 0.34 ^b	5.65 ± 0.750 ^b	5.95 ± 1.04 ^b	8.92 ± 0.87 ^b	13.92 ± 1.38 ^b
Obakekere	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	5.20 ± 0.41 ^b	5.82 ± 1.20 ^b	5.9 ± 1.11 ^b	9.01 ± 0.62 ^b	13.76 ± 1.01 ^b
Obanla	0.00 ± 0.00 ^a	1.40 ± 1.40 ^a	5.76 ± 0.37 ^b	6.03 ± 0.39 ^b	6.32 ± 0.44 ^b	12.50 ± 1.61 ^b	15.93 ± 0.82 ^b
Control soil	5.03 ± 0.56 ^b	8.03 ± 0.28 ^b	10.46 ± 1.40 ^c	16.33 ± 0.88 ^c	20.47 ± 1.35 ^c	23.87 ± 1.48 ^c	24.67 ± 1.32 ^c

CCP = COOP cocoa production; ACP = Alaranse cocoa processing unit; ICP = Ile Oluji cocoa production unit. Results of the mean of three triplicate results ± standard error of mean. Values of the same superscripts down the column are not significantly different at P < 0.05.

TABLE 8: LENGTH OF CAPSICUM FRUTESCENS LEAVES (CM) CULTIVATED ON SOIL SAMPLES COLLECTED FROM DIFFERENT LOCATIONS

Location	Age (Days)						
	17	19	21	23	25	27	29
Oda	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
Fiwasaye	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
Igbatoro	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
CCP	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
ACP	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
ICP	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a
Abaoyo	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	2.22 ± 0.18 ^b	2.35 ± 0.15 ^b	2.95 ± 1.06 ^b	3.82 ± 0.76 ^b	3.92 ± 1.38 ^b
Obakekere	0.00 ± 0.00 ^a	0.00 ± 0.00 ^a	2.20 ± 0.67 ^b	2.42 ± 1.09 ^b	2.78 ± 0.38 ^b	3.71 ± 0.18 ^b	4.06 ± 1.32 ^b
Obanla	0.00 ± 0.00 ^a	0.70 ± 0.70 ^a	2.27 ± 0.67 ^b	2.37 ± 0.67 ^b	2.83 ± 0.09 ^b	3.63 ± 0.18 ^b	3.93 ± 0.20 ^b
Control Soil	2.70 ± 0.15 ^b	3.00 ± 0.21 ^b	3.87 ± 0.67 ^c	4.53 ± 0.17 ^c	5.13 ± 0.19 ^c	5.57 ± 0.23 ^c	6.17 ± 0.17 ^c

CCP = COOP cocoa production; ACP = Alaranse cocoa processing unit; ICP = Ile Oluji cocoa production unit. Results of the mean of three triplicate results ± standard error of mean. Values of the same superscripts down the column are significantly different at P < 0.05.

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