Algerian Journal of Environmental Science and Technology
March edition. Vol.7. Nº1. (2021)
ISSN : 2437-1114
www.aljest.org

Effects of different levels of dried tomato corps by-products supplementation on carcass characteristics and fatty acid composition of broiler meat

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ARTICLE INFO

Article History:

Received ***: 13/12/2018***
Accepted ***: 19/11/2019***

Key Words:

tomato by product; arbor acres broilers; meat quality; fatty acid.

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ABSTRACT/RESUME

Abstract: *the aim of this study was to determine how a feeding plan characterized by different levels of tomato by products (TBP) supplementation influence the growth performance, carcass characteristics and fatty acid composition from arbor acres broilers. Sixty One-day-old chicks have been raised together and were fed during 20 days with a same standard diet. After these chicken were divided into three groups of 20 each. The first group was fed a basal diet without tomato by product TBP, while the other two groups were fed the basal diet after replacing some of maize with TBP at 10 % and 15% respectively. The lipid fraction of TBP showed a high degree of unsaturated fatty acid its contained 231,1± 2g/kg CP, 897,5 ± 2,5 g/kg DM and 16,9 g/kg carotenoids.The results of the animal experimentation show that, there was no significant difference between the experimental groups in term of performance and characteristics carcass. The saturated fatty acid content in the abdominal fat and thigh decreased significantly with increasing TBP inclusion, while polyunsaturated fatty acid increased.*

I. Introduction

Agro-industrial by-products represent one of the most important and promising energy, antioxidants and protein sources. Researchers are constantly searching for ways to improve the use of agricultural byproducts by including them in animal feed [1]. Examples of crop residues and agricultural by-products in Algeria are cereal bran, citrus pulp and tomato pulp. Industrial processing of tomato produces a large amount of waste. Algeria produces up to 1280570 tons of fresh tomatoes annually [2], most of which are used for processing in tomato cannery factories. When tomatoes are processed into products, 10 to 30% of their weight becomes waste or "pomace" [3]. It consists mainly of the skins, seeds and hard tissues of the whole tomatoes.

Tomato by-products have been considered an environmental nuisance for a long time. The material spoils quickly, emits a very foul odour and provides a breeding place for a variety of pests such as flies and mosquitoe. Feeding animals with tomato by-products is, therefore, a valuable way to prevent environmental contamination [4].

According to [3], tomato by products contains 5.1% moisture, 11.9% fat, 26.8% protein and 26.3% crude fiber. Moreover, it contains 13% more lysine than soybean protein [4,5], a good source of vitamin B, fair source of vitamin A and no known antinutritive factors [6]. It is also fiber rich feed resource and thought to act as a cholesterol reducing feedstuff in poultry products [4].

Tomatoes and tomato products are currently of renewed interest in both animal and human nutrition because they are excellent sources of natural antioxidants such as carotenoids, ascorbic acid, flavonoids and other related compounds. [7,8,9,]

Recent research has also shown that natural antioxidants can play a role in the prevention of chronic diseases [10]. There have been several reports showing that the antioxidants lycopene and lutein, which are abundant in tomatoes, may be of high beneficial effect on health [11, 12]. Therefore, incorporation of these natural antioxidants in the produced meat through tomato pulp feeding would be of particular interest to both the meat industry and the consumers.

Published information on the use of tomato by products as a feedstuff for poultry is rather limited. The results of an early study suggested that dried tomato pulp could be included in the diet of broiler chickens at 50 g/kg diet with-out adverse effects on bird performance [13,14]. Another study [15] showed that addition of tomato pulp in quail diets up to the level of 6%, did not affect growing and laying performance.

The aim of the present study was to investigate the effect of diet supplementation with dried tomato by products at levels of 10 and 15 %, substituting partially for maize, on performance, carcass characteristics and fatty composition acid of arbor acres broilers.

II. Materials and methods

II.1. Birds, housing and diets

The experiment was conducted in AVIGA-ROUIBA établissement, based in UPC CORSO, wilaya of boumerdes. Three compartments of 4m^2 of surface were arranged in this hen house. Before the arrival of the chicks, the building was washed with detergent, disinfected with 5% bleach. Subsequently, a crawl space of 15 days was observed, and the breeding equipment installed

Sixty one-day old chicks arbor acres (mixed sex), from the same hatchery (Barouagia), the animals were weighed and divided into three lots (n = 20) of homogeneous average weight (42±5g). The distribution of the batches within the building was made in order to have a homogeneous disposition of the subjects according to the studied regimes.

batch 1 (control) is fed by the standard diet, while the other two batch are fed by the standard diet which was substituted 10 and 15% of corn by the tomato by products. Ingredients and chemical composition of the experimental diets are presented in Table 1.

Tomato bay products are collected and dried in the free area and the shelter of sun to avoid the degradation of the active constituent of this matter (caroténoides and especially the lycopène)

Performance and carcass characteristics

The broilers of each replicate were weighed at 21, 28, 36, 42 and 50 d of age. Feed intake and the number of living chickens were recorded to calculate the average daily gain (ADG), average daily feed intake (ADFI) and feed to gain ratio (F/G) of every replicate [16].

ADG = (Final weight - Initial weight)/(Days of test - Number of broilers);

ADFI = Feed consumption/(Days of test - Number of broilers);

F/G = Feed consumption/Weight gain.

In order to evaluate of the carcass components, at the end of the experiment (47 d of age), 10 male broiler chickens from each replicate were randomly selected, individually weighed and sacrificed after 4 h feed deprivation. After the removing of viscera manually, the weight of the breast, thigh, liver, and pancreas were recorded and then calculated as a percentage of live body weight [16].

Organ index (%)= 100 x weight of organ/body live weight

Chemical analyses

Samples of Tomato bay products, diet and muscles were analyzed in duplicate for: dry matter, Ash, crude protein, Ether extract were determined by standard méthods (AOAC, 2000) . The Metabolizable Energy (ME) levels of feed ingredients was calculated using the formula ME (kcal kg^{-1} DM) = 3951+54.4 EE-88.7 CF-40.8 Ash [6].

The Total Carotenoid (TC) content was determined as reported by [17] with slight modifications. Briefly, 1g of tomato by product was homogenized for 30s at full speed with 20 ml of acetone using a vortex. 10 ml of petroleum ether was added to the acetone extract and then votrexed for 30 s. 10 ml of 0,1 NaCl was added to the acetone/ petroleum ether mixture and then votrexed for 30 s. after centrifugation of the homogenate (6000 rpm for 10 min), the supernatant was removed and then evaporated under vacuum at room temperature. The resulting TC concentrate was taken up in chloroform and the absorbance of the appropriately diluted extract was measured at 450 nm using a spectrophotometer. The concentration of TC in the extract was quantified using a standard calibration curve at five concentration levels (1, 2, 3, 4, 5 mg/ml)utilizing a pur syntitic β-carotene standard and then expressed as mg of β-carotene per g as fed basis.

The lipids were extracted from the samples of breast,thigh, perirenal fat, and the diets, using the chloroform/methanol method [18]. fatty acid composition was mesured after methylation of samples. fatty acid methyl esters were prepared with borotrifluoride methanol [19] and analysed on a perkin Elmer Autosysttm XLgas chromatograph equipped with fused silica gel capillary column (0,25mm x 30m), filled with a sationary phase (80% biscyanopropyl and 20% cyanopropylphenyl), using margaric acid (C17) as internal standard. the chromatography conditions used were: temperature program from 45 °c to 240 ° c at 20- 35 °c/min. the

Algerian Journal of Environmental Science and Technology
March edition. Vol.7. N°1. (2021)
ISSN : 2437-1114
www.aljest.org

injector and detector temperatures were maintained at 220°c and 280°c, respectively. resultats were exparessed as pourcentage of the fatty acid composition of diet, muscles an perirenale fat

Statistical analysis. Mean values were determined for each item in the initial analysis. An analysis of variance was conducted on the data for body wight, average daily gain, average daily feed intak and Duncan's new multiple range test was used to measure the significance of differences at $P < 0.05$.

III. Results and discussion

III.1.Composition and fatty acid profile of the tomato by products (TBP) and the diets

The ingredients and chemical composition of the TBP and of the tree diets are shown in table 1.The fatty acid pattern of the TBP ande the tree experimental diet are agiven in table 2.

Table 1. *Ingredient and chemical composition of tomato by products and experimental diet*

	TBP	compound diets					
		0%TBP		10%TBP		15%TBP	
		grower	finisher	grower	finisher	grower	finisher
Ingredient (g/kg as fed basis)							
maize		650	689	550	589	500	539
Soy beans		270	218	270	218	270	218
Wheat bran		50	60	50	60	50	60
Limestone		10	13	10	13	10	13
phosphate		10	10	10	10	10	10
Vitamin-mineral-premix		10	10	10	10	10	10
TBP		0	0	100	100	150	150
Chemical composition (g/kg as fed basis)							
Dry matter	897,5± 2,5	937,6	885,9	900,8	888,9	899,3	896,2
Crude ash	6,2±0,8	35,2±1,7	51,8±6,4	51±4	51,7±4	55,6±6,8	31,9±2,7
Crude protein	231 ± 2	186,6	184,5	203,6	196,7	193,2	202,5
Ether extract	72± 1,2	75,9	75,6	72,8	72,8	71,8	71,9
Crud fibres	325± 2	86,7	87,3	102,1	103,2	134,6	134,9
Total carotenoids, (µg/g)	16,9	6,89	10,15	8,13	9,21	8,74	9,82

Table 2. *Fatty acid contents (g/100g of total FA) in tomato by product (TBP) and experimental diets*

	TBP	0% TBP		10% TBP		15% TBP	
		grower	finisher	grower	finisher	grower	finisher
C14:0	trace	trace	trace	trace	trace	trace	0,22±0,014
C16:0	27,74±1,63	12,35±0,31	12,29±0,32	12,15±0,09	12,04±0,21	12,25±0,75	12,6±0,45
C16:1w7	1,78 ± 0,81	0,27±0,10	0,11±0,07	trace	0,35±0,08	0,45±0,07	0,35±0,07
C18:0	7,28 ±1,12	2,75±0,10	2,68±0,07	2,33±0,07	3,16±0,14	2,41±0,12	6,52±0,3
C18:1w9	18,54±2,12	30,44±0,04	31,46±1,15	30,46±0,8	30,13±0,65	29,79±0,33	25,04±0,02
C18:2w6	34,99±3,78	50,6±0,09	50,20±1,41	52,53±0,39	51,58±0,19	52,20±0,30	50,73±0,18
C18:3w3	9,06±1,06	2,59±0,49	2,29±0,04	2,52±0,43	2,21±0,09	2,83±0,07	2,13±0,03
C20:0	trace	0,52±0,21	0,49±0,020	trace	trace	0,42±0,03	2,32±0,03
C20:1w9	trace	0,39±0,02	0,41±0,12	trace	trace	trace	trace
∑SFA	35,02	15,65	15,46	14,45	15,62	15,09	21,67
∑MUFA	20,33	31,1	31,98	30,46	30,48	30,24	25,4

∑PUFA	44,55	53,19	52,49	55,04	53,795	55,03	52,86
∑n-6/n-3	3,86	19,53	21,92	20,76	21,49	18,44	23,81

The dry matter (DM) content of tomato by-product TBP was 897,5± 2,5 g/kg, which is similar to values reported by [20,21,22] but lower than the values reported by [23,24].The tomato by product (TBP)used in this study contained 231 ± 2g /kg crude protein (CP), which is comparable to the CP level found by [20], but lower than values reported by [21]. The level of EE content of TBP was 72 ± 1,2g /kg which is similar to values reported by [21, 22, and 23]. The ash value of DTP used in this study was similar to value reported by [20] but lower than values reported by [21]. The variations reported in chemical composition of tomato by product (TBP) could be due to various factors, including varieties of tomato, soil conditions, use of fertilizers, ripeness, tomato processing conditions, relative percentage of seed, skin, pulp and leaves in wet pomace and many more factors related to the drying process [20, 22, 24 and 25].

The carotenoids content of tomato by product TDP was 16.9 µg/g, which is similar to values reported by [26]. Among the agro-industrial by-products, tomato wastes are the only ones that are rich in carotenes, coming mainly from peel by-product where lycopene is several times more concentrated than in seed byproduct [7]; β-Carotene, having a higher concentration than lycopene, represents the major carotenoid in seeds [25].

Fatty acids were determined in dried tomato by product by using gas chromatography and their concentrations are presented in Table 2. The results showed that linoleic acid represents the major fatty acid C18:2n6 (34,99 ±3,78% of the total fatty acids) followed by palmitic acid C16:0, the main saturated acid (27,74±1,63%), than oleic acid C18:1n9 (18,54±2,12%) .The unsaturated fatty acids represent 64.88 % of the total fatty acids while the saturated fatty acids count for 35.02 %, revealing the domination of the unsaturated fatty acids over saturated fatty acids in dried tomato by product. Results of this study are in good agreement with previous findings by [26, 27].

In human nutrition, the high ratio of n-6:n-3 PUFA is known as a risk factor in cancers and coronary heart disease [27]. For tomato by product, this ratio was 3, 86, that is lower than the 12,57 and 15 by [27 and 28]respectively.

Table 3. *Effects of tomato by-product incorporation on performance of broilers.*

treatment	ADG,g	ADFI,g	F:G Ration
d21-d28			
0% TBP	54,14 ± 22,1^{a}	96,40 ± 8,42^{a}	1,96 ± 0,70
10% TBP	57,82 ± 28,91^{a}	98,05±1,69^{a}	1,69 ± 1,13
15% TBP	54,92 ±12,42 ^{a}	95,84± 2,26^{a}	1,8 ± 0,37
d28-d36			
0% TBP	110,86 ± 37,19 ^{a}	101,57±2,77^{a}	0,99 ± 0,03
10% TBP	78,5 ± 14,47^{a}	98,41± 1,83^{b}	1,27 ± 0,20
15% TBP	104,06 ± 20,65^{a}	96,55± 1,81^{b}	0,95 ± 0,17
d36-d42			
0% TBP	50,45 ± 20,02^{b}	121,17±7,44^{a}	2,64 ± 0,17
10% TBP	21,88 ± 9,08^{a}	115,44± 6,02^{a}	5,21 ± 2,37
15% TBP	26,78 ± 7,91^{b}	114,97± 4,26^{a}	4,53 ± 1,23
d42-d50			
0% TBP	109,08 ± 53,06^{a}	147,45 ± 3,22^{a}	1,35 ± 0,03
10% TBP	72,73 ± 46,92^{b}	127,61 ± 5,39^{b}	1,75 ± 0,037
15% TBP	80,28 ±33,33^{b}	126,71 ±7,19^{b}	1,57 ± 0,024
d21-d50			
0% TBP	55,81 ± 10,79^{a}	116,65 ± 3,88^{a}	2,13 ± 0,34
10% TBP	56,31 ±11,48^{a}	109,88 ± 0,78^{b}	2,00 ± 0,40
15% TBP	52,25 ± 8,34^{a}	108,52 ± 0,62^{c}	2,11 ± 0,32

Table 4. *Effects of tomato by-product incorporation on body weight of broilers*

	BW, g				
	d 21	d 28	d36	d42	d50
0% TBP	823,50 ± 92,5^{a}	1202,5±109,4^{a}	1625,25±254,7^{a}	1978,5±231,7^{b}	2498,00±321,9^{a}

Algerian Journal of Environmental Science and Technology
March edition. Vol.7. N°1. (2021)
ISSN : 2437-1114
www.aljest.org

10% TBP	740,74 ± 129,6[b]	1145,5± 241,8[a]	1695,00±409,6[b]	1848,2±184,2[a]	2430,05±313,10[a]
15% TBP	758,0 ± 94,27[ab]	1425,5±89,25[a]	1683,5±132,2[ab]	1871,00±159,8[b]	2325,75±210,2[a]

Table 5. *Effects of tomato by product incorporation on the carcass performance of broilers.*

	Thigh %	Breast %	Liver %	Gizzard %	Heart %	Abdominal fat %
0% TBP	23,21 ± 1,21[a]	26,34 ± 2,02[a]	2,24 ± 0,32[a]	1,58 ± 0,36[a]	0,52 ± 0,06[a]	0,93 ± 0,22[a]
10% TBP	22,77 ± 1,14[a]	26,07± 2,30[a]	2,52 ± 0,32[a]	1,86 ± 0,24[a]	0,49 ± 0,08[a]	1,02 ± 0,40[a]
15% TBP	22,13 ± 1,57 [a]	26,95±1,95[a]	2,26 ± 0,17[a]	1,62 ± 0,33[a]	0,50 ± 0,07[a]	0,87 ± 0,32[a]

III.2. Growth performance

Broiler growth performance is presented in Table 3. No differences in ADG, ADFI and F:G ratio of broilers were observed among the 3 treatments ($P > 0.05$) from both d 21 to 28. However, the ADG of broilers in treatment 0% TBP was higher than those of treatment 10% TBP and 15% TBP for d 28 to 36, d 36 to 42 and d 42 to 50 periods ($P < 0.05$). Concerning, the ADFI of broilers was higher of treatment 0% TBP than those of treatment 10% TBP and 15% TBP for d 28 to 36, d 42 to 50 and d 21 to 50 periods ($P < 0.05$).Throughout the entire trial, the F:G ratio was lower of treatment 10% TBP than of treatments 0% TBP and 15% TBP. Moreover, there were no significant differences appeared in growth performance between treatments 10% TBP and 15% TBP ($P > 0.05$).
Body weight data of broilers on d 21, 28, 36, 42 and 50 are shown in Table 4. On d 28, and 50, there were no significant differences in BW among the 3 treatments ($P > 0.05$). However, BW of treatment 0% TBP was higher than those of treatments 10% TBP and 15%TBP on both d 21 and 36 ($P < 0.05$). On the other hand, BW of treatment 10% TBP was higher than those of other treatments on d 42. But it can be drawn at the end of the experimentation (d52) that there is no significant difference in BW for the three treatments. These results are in agreement with those found for broiler chickens fed diets supplemented with 5% dried tomato pulp [13] and quails given diets supplemented with dried tomato pulp up to 6.5% [14].
Carcass characteristics are reported in table 5. The supplemented diet of tomato waste has no effect ($p > 0.05$) on the carcasses performance even for the liver which plays an important role in the lipid metabolism. Therefore, depending on the amount of dietary level present in the diet, the weight of that organ may be altered [29] mainly as a consequence of the increased metabolic activity. Data on body/liver ratio found in this work, however, were not affected by the different levels of tomato by products (TBP) added to the poultry diets.

III.3.Fatty acids composition

Results of the fatty acids composition in abdominal fat and thigh of broilers are reported in table 6 and 7 respectively. As expected, the fatty acids profile of abdominal fat and thigh was influenced by fatty acids composition of the diet, in fact the lipids of tomato by product (TBP) are poor in ALA (C18:3n-3 = 9,06) but riche in LA (C18:2n-6 = 34,99).as a consequence , the abdominal fat an thigh of broilers fed a diet containing tomato by product had a higher proportion of LA (C18:2n-6) than the abdominal fat and thigh of broilers fed 0% tomato by product. The proportion of LA (C18:2N-6) increases with the increase in percentage of tomato by product incorporated in the diet, the values found in this study are of order 15,93±0,06 and 16,83± 2,76 for abdominal fat and thigh respectively in the diet of 10%. 20,70 ±0,29 and 17,06± 3,11 in the diet 15%. The increase in LA might be explained on the basis of the fatty acids composition of the seed content of tomato by product. These results are in agreement with those found by [30], comparing rabbits fed a tomato by product diet with rabbits fed an alfalfa-based diet. Linoleic acid (C18:2n-6) is an essential fatty acid that acts as the primary precursor of n-6 PUFAs [31]. Linoleic acid in the diet can suppress lymphocyte proliferation in rats [32]; and alfa-linoleic acid can prevent cardiovascular disease [33], which all could be beneficial for human health through consumption of broiler meat.
As far as the saturated FAs content was concerned, a decrease in the thigh and abdominal fat with increasing tomato by product inclusion level was found for C16:0 in abdominal fat and C16:0, C18:0 in thigh of broilers. The lowest value of saturated fatty acids was observed in the treatment 15% TBP

(SFA= 36, 00) for abdominal fat, whereas in the thigh it was observed at 10% (SFA= 31, 41). The content of unsaturated fatty acid in abdominal fat and thigh of broilers increases linearly with the level of tomato by product in the diet.

Table 6. *Fatty acid composition (g/100g of total FA; means± S.E; n=3) in abdominal fat of broilers fed experimental diets (% of tomato by products –TBP).*

	0%TBP	**10%TBP**	**15%TBP**
C14:0	0,68±0,01	0,65±0,01	0,72±0,01
C14:1	0,17±0,00	0,17±0,01	0,14±0,00
C16:0	28,45±0,66	28,54±0,24	26,98±0,31
C16:1w7	6,85±0,21	7,16±0,07	5,50±0,17
C18:0	7,65±0,33	7,68±0,11	7,82±0,33
C18:1w9	37,86±0,61	37,87±0,13	35,21±0,18
C18:2 n-6	15,78±0,76	15,93±0,06	20,70±0,29
C18:3n-3	0,78±0,03	0,75±0,01	1,11±0,01
C20:0	0,34±0,09	0,29±0,01	0,48±0,03
C20:1 n-9	0,53±0,07	0,47±0,01	0,65±0,03
C20:2	0,17±0,04	0,12±0,01	0,22±0,01
C20:4n-6	0,10±0,03	trace	trace
∑SFA	37,11±1,10	37,15±0,36	36,00±0,68
∑MUFA	45,41±0,88	45,67±0,22	41,49±0,39
∑PUFA	16,83±0,86	16,79±0,07	22,02±0,31
∑n-6/n-3	20,23	21,24	18,64

Table 7. *Fatty acid composition (g/100g of total FA; means± S.E; n=3) in thigh of broilers fed experimental diets (% of tomato by products –TBP).*

	0%TBP	**10%TBP**	**15%TBP**
C14:0	0,52± 0,05 ^{a}	0,60±0,09^{a}	0,53± 0,05^{a}
C14:1	0,11± 0,02 ^{a}	0,17±0,04 ^{a}	0,13± 0,02 ^{a}
C16:0	22,62± 1,48 ^{a}	23,94±2,73 ^{a}	23,55± 2,15^{a}
C16:1w7	5,65± 0,48 ^{a}	6,42± 0,27^{a}	5,67± 0,36 ^{a}
C18:0	7,75± 0,54 ^{a}	6,43±2,03 ^{a}	7,37± 0,93 ^{a}
C18:1w9	35,65± 1,81 ^{a}	33,01± 5,16^{a}	34,70± 1,70 ^{a}
C18:2 n-6	15,97 3,69^{a}	16,83± 2,76^{a}	17,06± 3,11
C18:3n-3	0,85± 0,12^{a}	1,34± 0,74^{a}	0,78± 0,23 ^{a}
C20:0	0,32 ±0,12^{a}	0,41± 0,18^{a}	0,24± 0,10^{a}
C20:1 n-9	0,80± 0,06^{a}	0,69± 0,17^{a}	0,97± 0,42^{a}
C20:2	0,28±0,03 ^{a}	0,64± 0,45^{a}	0,64± 0,45 ^{a}
C20:4n-6	0,79±0,07 ^{a}	0,86± 0,26^{a}	0,81± 0,05^{a}
C20 :3n-6	0,43± 0,32^{a}	0,38 ± 0,22^{a}	0,27 ± 0,40^{a}
∑SFA	32,21±1,10	31,48±0,36	31,69±0,68
∑MUFA	42,21±0,88	40,29±0,22	41,47±0,39
∑PUFA	18,04±0,86	18,41±0,07	18,92±0,31
∑n-6/n-3	18,75	12,55	21,87

Algerian Journal of Environmental Science and Technology
March edition. Vol.7. Nº1. (2021)
ISSN : 2437-1114
www.aljest.org

IV. Conclusion

In conclusion, the results of the present study indicated that dried tomato by product can be included in diets of arbor acres broilers up to a level of 15% without any adverse effect on performance, carcass characteristics and meat quality. With a higher preference for meat from broilers fed TBP diet than for from the 0% TBP group. The enrichment of the broilers diet with TBP allows the production of broilers meat with a good degree of unsaturation fatty acid and low saturation of fatty acid, which constitutes an important nutritional benefit to humans. Furthermore, our results indicate that a diet integrated with 15% TBP or higher could positively affect the fatty acid profile.

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Please cite this Article as:
Ferhoum F., Benakmoum A., Effects of different levels of dried tomato corps by-products supplementation on carcass characteristics and fatty acid composition of broiler meat., ***Algerian J. Env. Sc. Technology, 7*****:1 (2021) 1769-1776**