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NUTRITIONAL QUALITY OF *Jatropha curcas* SEEDS AND EFFECT OF SOME BIOLOGICAL AND CHEMICAL TREATMENTS ON THEIR ANTINUTRITIONAL FACTORS

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ABSTRACT

The physical characteristics of Egyptian *Jatropha curcas* seeds were studied. The average of whole seed mass, kernel weight, shell weight, percentage kernel mass of whole seeds and percentage shell mass of whole seeds were 0.69 g, 0.47 g, 0.22 g, 68.12 % and 31.88 %, respectively. Biochemical composition proved that *J.curcas* seeds are a good source of protein (32.88 %), oil (27.36 %) and carbohydrates (30.11 %). The seeds are rich in various micro-elements, i.e. Mn, Fe, and Zn which recorded 28.37, 0.38 and 47.13 mg/kg, respectively as well as macro-elements, i.e., K, Ca, Na, Mg and P, which recorded 103.13, 34.21, 8.44, 109.89 and 185.17 mg/kg, respectively. The seeds contain 52.59 mg/100g, 25.58 mg/g, 39.95 mg/100g and 1.51 g/100g of phytic acid, trypsin inhibitor activity, total phenols and saponins, respectively. Therefore, it could be inferred that the seeds is nutritionally promising because of its high nutrient content and low antinutrient level. The effect of some biological treatments (soaking, germination and roasting) and some chemical treatments ($NaHCO_3$, ethanol extraction and NaOH) were successful inactivating the antinutrients.

Keywords: *Jatropha curcas*, nutrient, antinutrient, mineral content, chemical composition.

INTRODUCTION

Jatropha curcas (physic nut or purging nut) the new cultivated and promising crop is convcient to adapt in Egypt for increasing the local planted production (MSEA, 2008). The primary use of *J. curcas* seeds in Egypt is for Jatropha oil extraction, which is a good alternative to biofuel, and has proven success used either independently or by mixing the diesel to operate farm machinery, household lighting, in Soap and Candles (El-Gamassy, 2008).

J. curcas is native to Central America and has become naturalized in many tropical and subtropical areas, including India, Africa, and North America. Originating in the Caribbean, Jatropha was spread as a valuable hedge plant to Africa and Asia by Portuguese traders (Fairless, 2007).

Growers of Jatropha are increasingly demanding seeds in Egypt for cultivation for the production of biofuel. In 2004–05, the area planted with *J. curcas* was about 100 hectare, increased seven times to about 700 hectare in 2007. The rate of increase is 175%, which is really very high **(**MSEA, 2008).

In Egypt were planted about 70 hectare on wastewater treatment in Luxor, Ismailia, Suez and Giza. This is grown in hectare between 350 to 500 saplings, and seed production range between 1.5 to 12 tons per hectare or the yield per hectare is up to 5 tons seed given about 1.85 tons of oil in the year (El- Gamassy, 2008).

J. curcas a member of the *Euphorbiaceae* family is a multipurpose tree of significant economic importance because of its several industrial and medicinal uses (Makkar *et al*., 2008a). Jatropha bush and have multiple uses it well to produce outstanding biodesil as fuel and due to fires without emissions that pollute the environment, so-called oil friend of the environments is also used for lighting and several other industrial purposes (El- Gamassy, 2008).

Jatropha grow throughout most of the tropics. It survives on poor stony soils and can be used to reclaim land (Munch and Kiefer, 1989). Jatropha plants start yielding from the second year of planting, but in limited quantity. If managed properly, it starts giving 4-5 Kg of seed per tree production from the fifth year onwards and seed yield can be obtained up to 40-50 years from the day of planting (Kumar *et al*., 2003). The seed weights ranged from 0.53 to 0.86 g and the kernel contains 22 - 27 % protein and 57 - 63 % oil (Oladele and Oshodi, 2008). These limits indicating that Jatropha is a good nutritional value. The seed kernels are known to contain highly oil, which can be used as fuel directly or as a substitute to diesel in the transesterified form. The oil is also used for making candles, soap, lubricants and varnishes and is used for illumination. The seed cake can be a good protein source for humans as well as for livestock (Makkar *et al*., 2008a).

J. curcas seeds are highly toxic to a number of animal species due to the presence of some types of antinutritional components such as phytic acid, trypsin inhibitor, phenolic compounds and saponins at high amounts (Makkar *et al*., 2008b). So, the seed cake obtained from oil extraction didn't use in animal diet (Makkar *et al*., 2008b). The decreases in the levels of antinutritional factors to safe limits may be caused by thermal degradation, soaking in distilled water, germination, and extraction of methanol (Yasmin *et al*., 2008; Magdi, 2007; Ramakrishna *et al.*, 2006; Aderibigbe *et al*., 1997).

The objective of the present study was to demonstrate the nutritional quality of Egyptian *J. curcas* seeds. Also, the effect of some processing methods on some antinutrional factors of *J. curcas* seeds will be study to decrease the antinutrional factors to safe limits.

MATERIALS AND METHODS

Materials

Sample materials:

Jatropha species (*Jatropha curcas L.)* were purchased from Luxor city, Luxor governorate, Egypt that harvested at April, 2009. The sample was cleaned manually to remove all foreign materials such as dust, dirt, small branches and immature seeds. The cleaned and graded seeds were de--hulled to gain access to a cream-coloured endosperm, which is the sample material. The sample materials were blended to powder (0.5 mm) form with a high-speed blender (Braun KMM 30 mill), type 3045, CombiMax (Germany).This was stored in an airtight polyethylene bags and kept in a refrigerator prior to analysis.

Chemicals and reagents

All chemicals and reagents were purchased from Sigma chemical Co. (St. Louis, Mo, USA). The used water was distilled using water distillation apparatus (D 4000).

Trypsin enzyme from bovine pancreas type III; 16.500 BAEF Umg^{-1}, was purchased from Sigma chemical Co. (St. Louis, Mo, USA).

Micro-elements, i.e. lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), cobalt (Co), zinc (Zn), manganese (Mn), copper (Cu),and iron (Fe) as well as macro-elements, i.e. potassium (K), calcium (Ca), phosphorus (P) and sodium (Na) were provided by (Merck, Darmstadt, Germany). The working standards were prepared from the individual stock solution (1000 mg/L).

Methods:

Physical properties of Jatropha seeds

Thirty seeds of Jatropha were randomly taken and the average weight of the seeds was estimated. The seeds were cracked using a mechanical cracker, the shells were carefully removed, and the weights of the kernel were recorded. Further, the average shell weight was calculated from the total seed weight minus kernel weight of the respective seeds.

Effect of some biological and chemical treatments on the antinutrients *of J. curcas* seeds

Biological treatments:

1) **Soaking:** Seeds were soaked in distilled water at ratio of 1:10 (w/v) at room temperatures (25 ± 2°C) for 12 h, then dried in a hot air oven at 40 ºC to a constant weight. The samples were milled in a Braun (KMM 30) mill to pass through a 0.5 mm sieve and stored in plastic bags until required for further analysis.
2) **Germination:** The seeds were germinated at room temperatures (25 ± 2 °C) for 5 days by keeping them in trays lined with wet filter paper. The germinated seeds were dried in a hot air oven at 40 ºC to a constant weight. The samples were milled in a Braun (KMM 30) mill to pass through a 0.5 mm sieve and stored in plastic bags until required for further analysis.
3) **Roasting:** The seeds were generally roasted on trays at 160 ºC/30 min. according to the method of (Yanez *et al*., 1986).

Chemical treatments

The whole seeds and kernel were divided into five equal experiments (500 g of each). The first experiment not treated as control. The second experiment was treated with 0.07% $NaHCO_3$ solution in the ratio of 1:5 (w/v) and immediately autoclaved at121ºC for 25 min. The samples were dried in hot air oven at 40 ºC. Experiment three was extracted with 90 % ethanol for 2 h. at room temperature (25 ± 2°C) with constant stirring. The sample to solvent ratio was 1:10 (w/v). The solvent was removed by filtration and the residue was dried in hot air oven at 40 ºC. The fourth experiment sample, after treatment similar to experiment (3) was air-dried, mixed with 0.07% $NaHCO_3$ solution in the ratio of 1:5 (w/v) and subjected to autoclaving at121ºC for 25 min. and the residual was dried in hot air oven at 40 ºC. In

experiment five, the seeds (300 g) were weight into 1000 ml beaker, followed by the addition 4 % NaOH solution to form a paste. The paste was heat treated (autoclaving at 121ºC for 25 min.), then dried by hot air oven at 40 ºC. The dried paste was grounded using a simple laboratory mill to give the sample. Consequently, the grounded sample was washed with distilled water three times, prior to milling.

Sample preparation

The kernel and whole seeds were grounded, using a mechanical grinder (Braun KMM 30 mill), and defatted in soxhlet apparatus, using diethyl ether (boiling point of 40-60 ºC), for 16 h. The defatted seed was air dried at room temperature (25 ± 2°C) and stored in a separate plastic container at 4 ºC.

Analytical methods

All *J. curcas* samples (whole seeds, kernel and shell) were analyzed for moisture, crude protein, oil and ash contents according to the standard methods of AOAC (2000). The method of Pearson (1976) was used for the determination crude fiber. While total carbohydrates were determined by the phenolsulphoric acid method using glucose as standard (Dubois *et al*., 1956). Reducing sugars were estimated by 3, 5- dinitrosalicylic acid (DNS) method using D (-) fructose (Mw= 180.16, Fluka) as standard (Miller, 1959) and non-reducing sugars were expressed as difference between total carbohydrates and reducing sugars. The values of these compounds are reported on dry weight basis (g/100 g dry solids).

Minerals

Mineral contents, i.e. copper (Cu), magnesium (Mg), manganese (Mn), iron (Fe), zinc (Zn), lead (Pb) and Nickel (Ni) were determined according to the method of A.O.A.C (2000) using Atomic Absorption Spectrophotometer, Perkin-Elmer 2380 manufacture (USA).The flame photometer was applied for macro-elements: potassium (K), calcium (Ca) and sodium (Na) determination according to the methods described by Pearson (1976). While Spectrophotometric method was used for determination of the phosphorus (P) content of the tested samples using ammonium molybdate as outlined in the A.O.A.C (2000).

Determination of antinutrional components

Phytic acid: The determination of phytic acid was applied according to the method described by Mohamed *et al*. (1986) using chromogenic reagent. The color was measured at 830 nm against a blank. The results were calculated as mg phytic acid/100 g dry sample using standard phytic acid.

Trypsin inhibitor activity (TIA): The determination of trypsin inhibitor activity was applied according to the method of Smith *et al*. (1980), except that the enzyme was added last, as suggested by Liu and Markakis (1989). Results are expressed as mg trypsin inhibited per g of dry sample.

Total phenolics: The extraction and determination of total phenolics were applied by spectrophotometric method described by Makkar *et al.* (1997). Total phenolics were quantified by the Folin-Ciocalteu reagent and results were expressed as tannic acid equivalents.

Total saponins content: The determinations of total saponins were applied using a spectrophotometric method described by Hiai *et al.* (1989). The concentration of saponins were read off from a standard curve of different concentrations of diosgenin in 80 % aqueous methanol and expressed as diosgenin equivalents.

Statistical analysis

The data were statistically analyzed by analysis of variance and least significant difference (L.S.D.) at 0.05 levels according to the method described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Physical properties of *J. curcas* seeds

Physical properties of *J. curcas* seeds were determined (Table1).

Table 1: Physical characteristics of *J. curcas* seeds

Item	Level (on dry weight basis) ± SD
Whole seed of weight (g)	0.69 ± 0.2
Kernel weight ((g)	0.47 ± 0.3
Shell weight (g)	0.22 ± 0.3
Kernel, % of whole seed	68.12 ± 4.42
Shell, % of whole seed	31.88 ±1.91

Mean of thirty seeds

Data presented that average mass of whole thirty seeds was 0.69 g, and the average kernel weight was 0.47 g, as well as the shell average weights was 0.22 g. Data proved also, that the percentage kernel and shell mass to whole seeds were 68.12 % and 31.88 %, respectively. Similar results reported by Herrera *et al*. (2006). However, the values of the percentage kernel weights found in this study were larger than that detected by Makkar *et al*. (1998).

Biochemical composition of raw *J. curcas*:

Biochemical composition of the whole seeds, kernels and shells of untreated seeds (raw) of *J. curcas* are presented in Table 2. Data shows that whole seeds contains 5.58 % moisture, 32.88 % protein, 27.36 % oil, 5.68 % ash, 3.81 % fiber and 30.11 % total carbohydrates (reducing and non-reducing sugars). These values are very similar to those reported by Makkar *et al*. (1998). However, Akintayo (2004) reported lower value of protein (24.60 %) and higher value of oil (47.25 %) with moisture content 5.54 %. On the other hand, Ogbobe and Akano (1993) reported that the seed of Jatropha gossipifolia contains crude oil, protein, fiber, and carbohydrates at levels 35.8%, 13.40 %, 9.25 % and 30.32 %, respectively.

Regarding to kernel seeds data indicate that oil was the mainly composed followed by protein with low ash, crude fiber and total carbohydrates (Table 2). Moisture content was 4.46 % is obviously lower than the 10 % moisture content limit recommended for storage stability of flours (Makkar *et al.,* 1998).These results are agreement with that reported by Herrera *et al*. (2006).

Table 2 proved that the shells of *J. curcas* seeds composed mainly of fiber with very little protein, oil and total carbohydrates, that indicating poorly nutritional value. However, the shells consider a good source of fuel as it has high gross energy. Moisture content of shells was 6.54 % which the shell moisture content (< 10 %) could be partly responsible for the non deterioration of seeds over a long period (Makkar *et al*., 1998).

Table 2: Chemical composition of whole, kernels and shells from raw seeds of *J. curcas*

Components %	Values (on dry weight basis)			LSD at 5 %
	Whole seeds	Kernel seeds	Shells	
Moisture	$5.58^{b} \pm 2.0$	$4.46^{c} \pm 4.0$	$6.54^{a} \pm 3.0$	6.21
Protein	$32.88^{a} \pm 3.98$	$29.91^{b} \pm 4.28$	$4.32^{c} \pm 3.0$	7.43
Oil	$27.36^{b} \pm 3.98$	$47.18^{a} \pm 2.71$	$1.28^{c} \pm 4.0$	7.21
Ash	$5.68^{b} \pm 3.01$	$5.42^{c} \pm 2.0$	$6.21^{a} \pm 4.0$	6.21
Fiber	$3.81^{b} \pm 3.96$	$2.48^{c} \pm 3.0$	$83.50^{a} \pm 0.03$	6.24
Reducing sugars	$17.10^{a} \pm 0.04$	$12.62^{b} \pm 2.97$	$1.68^{c} \pm 4.0$	0.07
Non-reducing sugars	$13.01^{a} \pm 3.0$	$2.34^{c} \pm 0.05$	$2.89^{b} \pm 4.0$	8.16
Total carbohydrates	$30.11^{a} \pm 0.03$	$14.96^{b} \pm 3.98$	$4.57^{c} \pm 3.0$	6.62

-All values are means of triplicate determinations ± standard deviation (SD).
- Means within rows with different letters are significantly different (P < 0.05).

It could be concluded that significantly differences (P<0.05) were detected between the whole seeds, kernel seeds and shells among the components of moisture, protein, oil, ash, fiber and carbohydrates contents.

Crude oil is the most abundant lipids found in nature. High value of oil (47.18 %) was recorded with kernel of *J. curcas* seed. This oil content is much higher than the value recorded for other much seeds. The crude fiber is very high (83.50 %) in Jatropha shells and lower in whole and kernel seeds. Fiber content is a significant component of the diet. It increases stool bulk and decreases the time that waste materials spend in the gastrointestinal tract. It is commonly used as an index of value in poultry and feeding stocks feeds (Eze and Ibe, 2005). Crude protein values of 32.88 and 29.91 % observed for whole and kernel *J. curcas* seeds are obviously much higher than most legumes and grains. Carbohydrate content (30.11 %) of whole seeds of *J.curcas* detected is much higher than most grains. They are essential for the maintenance of plant and animal life and also provide raw materials for many industries.

Antinutrional factors of raw *J. curcas*:

The antinutrient (phytic acid, trypsin inhibitor, total phenols, and saponins) contents of the defatted whole *J. curcas*, kernel and shell seeds were shown in Table 3. In whole seeds, phytic acid (mg/100g), trypsin inhibitor activity (mg/g), total phenols (mg/100g) and saponins (g/100g) were 52.59, 25.58, 39.95 and 1.51, respectively. In kernel seeds these factors were increased significantly (P<0.05) except its content of phytic acid which decreased significantly. On the other hand, phytic acid and total phenols contents were increased significantly (P<0.05) with shells compared with whole seeds. However, the other factors (TIA and saponins) were decreased significantly.

These results demonstrate the high levels of phytic acid in raw *J. curcas.* The phytate content of Jatropha seed varied according to the variety (Reddy and Pierson, 1994). In the present study significant differences (P<0.05) were observed between the contents of phytic acid in whole seeds or kernel and shells. These indicate that the consumption of Jatropha meal can decrease the bioavailability of minerals (Oladele and Oshodi, 2007)*;* especially Ca and Zn. Phytates have also been implicated in decreasing protein digestibility by forming complexes and also by interacting with enzymes such as trypsin and pepsin (Reddy and Pierson, 1994).

Trypsin inhibitor activity (TIA) content is high in *J. curcas.* Highly significant differences (P<0.05) in kernel seeds compared with whole seeds and shells were observed. Similar results obtained by Makkar *et al*. (1998) who reported that the trypsin inhibitor activity of Jatropha ranged between 18.4 to 26.85 mg/ g.

Regarding to total phenols, data showed that the highest significant differences (P<0.05) was detected with kernel followed by shells and whole seeds. *J. curcas* seeds are highly toxic to a number of animal species due to the presence of some types of antinutritional components such as total phenolics compounds (Makkar *et al*., 2008b & Chivandi *et al*., 2004). Phenolic compounds are commonly found in both edible and non-edible plants, and they have been reported to have multiple biological effects, including antioxidant activity (Kahkonen *et al*., 1999). The presence of phenolic compounds in injured plants may have an important effect on the oxidative stability and microbial safety (Hollman *et al*., 1996).

Saponins in *J. curcas* were lower than other antinutritional factors under study. However, significant differences was reported among whole seeds, kernel and shells and the highest significant differences ((P<0.05) detected with kernel followed by whole seeds and shells. Saponins, which are natural triterpene plant glycosides found in many plant species, have been of great interest recently because of their physiological activities (Fenwick *et al*., 1991).

Table 3 :Antinutritional factors of whole, kernels and shells from raw seeds of *J. curcas*

Antinutrional factors	Values (on dry weight basis)			LSD at 5 %
	Whole seeds	Kernel seeds	Shells	
Phytic acid (mg/100g)	52.59 ^{b} ±0.85	34.37 ^{c} ± 0.25	61.10 ^{a} ± 0.03	1.02
Trypsin inhibitor activity (TIA mg/g sample)	25.58 ^{b} ± 2.82	33.26 ^{a} ± 0.03	15.83 ^{c} ± 3.98	6.50
Total phenols (mg/100 g)	39.95 ^{c} ± 0.65	75.93 ^{a} ± 4.14	43.91^{b} ± 4.42	4.83
Saponins (g/100g)	1.51 ^{b} ± 2.0	2.63 ^{a} ± 0.04	0.65 ^{c} ±0.03	6.21

-All values are means of triplicate determinations ± standard deviation (SD).
- Means within rows with different letters are significantly different (P < 0.05).

Minerals contents of *J. curcas*:

Mineral contents of Jatropha samples (whole, kernel and shell seeds) are shown in Table (4). Results indicate that the highest mean level of micro elements in the whole seed and shell was manganese which recorded 28.37

and 12.91 mg /kg d.b, respectively. However, in whole seeds, the highest mean level (47.13 mg/kg d.b) was recorded with zinc. Regarding to iron in whole seeds, manganese and iron in kernel seeds as well as iron and zinc in shell samples were detected at lower levels. On the other hand, copper, nickel and lead were not detected in any of the analyzed samples. These results confirmed by statistical analysis which data proved that highly significant differences (P<0.05) were observed with manganese in whole seeds, iron in shells and zinc in kernel seeds compared with other factors.

Table 4: Mineral contents of whole, kernels and shells from raw seeds of *J. curcas*.

Elements	Concentrations mg/kg (on dry weight basis)			LSD at 5 %
	Whole seeds	Kernel seeds	Shells	
Micro elements				
Copper (Cu)	nd	Nd	nd	-
Manganese(Mn)	28.37^{a} ± 0.03	0.79 ±0.03	12.91^{b}±3.03	5.98
Iron (Fe)	0.38 ^{c} ± 3.99	0.44^{b}±4.0	7.31^{a} ± 3.0	7.39
Zinc (Zn)	47.13^{a} ± 0.03	42.13^{b}±0.02	1.07 ^{c} ± 0.01	7.43
Nickel (Ni)	nd	Nd	nd	nd
Lead (Pb)	nd	Nd	nd	nd
Macro elements				
Potassium (K)	103.13 ^{b}±0.03	109.52^{a}±4.42	34.24 ^{c} ±1.9	7.21
Calcium (Ca)	34.21^{b} ±4.47	51.41^{a} ± 3.49	28.01^{c} ±0.52	0.60
Sodium (Na)	8.44 ^{c} ± 3.0	8.83 ^{b} ± 2.01	18.22 ^{a}±3.95	6.18
Magnesium (Mg)	109.89 ^{a}±0.03	102.29^{b}±0.03	5.04 ^{c} ± 0.03	7.21
Phosphorus (P)	185.17 ^{a}±2.21	165. 33 ^{b}±1.0	2.59 ^{c} ±3.0	n.s

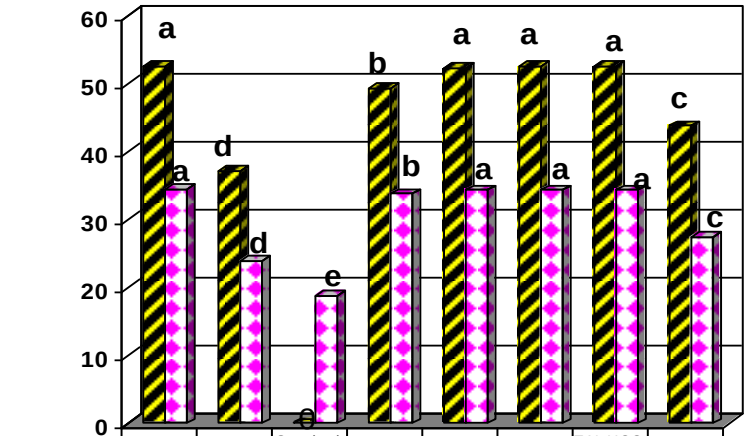
- Means within rows with different letters are significantly different (P < 0.05).
- nd : not detectable
- n.s: non-significant

The contents of macro elements were varied in different samples. Kernel seeds were reached by potassium (109.52 mg/kg), calcium (51.41 mg/kg), magnesium (102.29 mg/kg) and phosphorus (165.33 mg/kg). Statistical analysis proved that highly significant differences (P<0.05) was detected with kernel seeds with these elements compared with whole seeds and shell samples. However, the highest level of sodium (18.22 mg/kg) was detected in shell samples. On the other hand, moderate levels of K, Ca, Mg and P were observed in whole seeds. Beside, these elements were found at lower levels in shell samples except Na. Similar results obtained by Oladele and Oshodi (2007). The seeds could therefore be referred to as a good source of calcium, magnesium, potassium, phosphorus and zinc.

Effect of some biological and chemical treatments on the antinutrients of *J. curcas* seeds

1. Effect of different treatments on phytic acid content

Phytic acid content of *J. curcas* seeds after soaking in distilled water was determined (Figure 1). Data showed that phytic acid content decreased significantly (P<0.05) by 29.36 % and 30.46 % in whole and kernel seeds, respectively. This reduction may be attributed to leaching out of phytate ions into soaking water under the influence of concentration gradient, such losses may to taken as a function of changed permeability of seed coat (Duhan *et al.,* 1989). These results are agreement with that reported by Ramakrishna *et al*. (2006).



	Control.	Soaking	Germination	Roasting	NaHCO3	Ethanol	E,NaHCO3	NaOH
Whole seeds	52.59	37.15	0	49.34	52.24	52.56	52.53	43.8
Kernel seeds	34.37	23.9	18.88	33.8	34.34	34.33	34.35	27.5

-All values are means of triplicate determinations ± standard deviation (SD).
- Means within rows with different letters are significantly different (P < 0.05).

Figure 1: Phytic acid content (mg/100g on dry weight basis) of *J. curcas* seeds as affected by some biolological and chemical treatment

Fig 1 shows that the phytic acid content decreased significantly (P<0.05) after soaking in distilled water with kernel seeds and the reduction was 45.07 % due to leaching out of this compound in water. Similar results obtained by Yasmin *et al.* (2008).

Phytic acid content in defatted whole and kernel seeds as affected by roasting (Figure1) slightly affected significantly (P<0.05). These indicate that phytate constitutes a major heat-resistant antinutritive component in Jatropha meals. These results coincide with those obtained by Makkar *et al.* (1998).

Phytic acid content as affected by 0.07 % NaHCO3 followed by heat treatment using autoclave at 121ºC for 25 min (Figure 1) was not affected significantly (P<0.05) in either whole or kernel seeds. These results agreement with those reported by Aderibigbe *et al.* (1997). The high level of phytate present in defatted Jatropha might decrease the bioavailability of minerals (especially Ca^{2+} and Fe^{2+}). Phytates have also been implicated in decreasing protein digestibility by forming complexes and also by interacting with enzymes such as trypsin and pepsin (Reddy and Pierson, 1994).

Extraction of whole and kernel seed samples by 90 % ethanol for 2 h at room temperature (25 ± 2 °C) with constant stirring on phytic acid content (Figure 1) showed that the phytic acid level was not affected significantly (P<0.05). These results agree with those reported by Makkar *et al*. (1997).

Extraction of whole and kernel seed samples by 90 % ethanol for 2 h and treated by 0.07 % $NaHCO_3$ and autoclaved at 121ºC/ 25 min on phytic

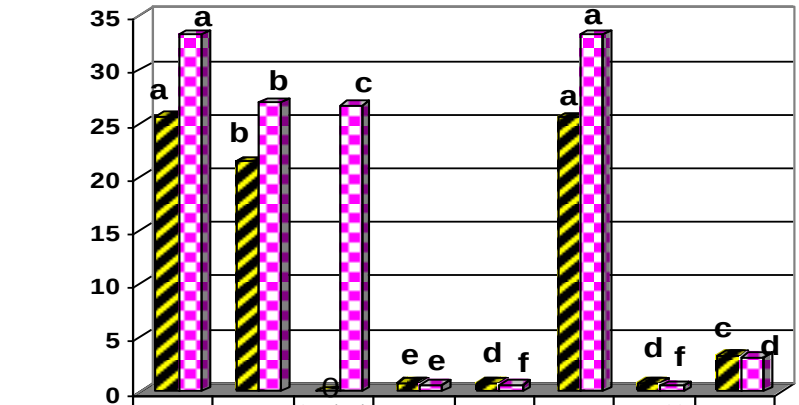
acid content (Figure 1) proved that the phytic acid level was not affected significantly (P<0.05) of both whole and kernel seeds. The values obtained are very close to those reported by Makkar *et al*. (1997).

The effect of sodium hydroxide treatment followed by washing with distilled water decreased significantly (P<0.05) the phytic acid content by about 16.71 % and 19.99 % of defatted whole and kernel seeds, respectively (Figure 1). These results are in agreement with those reported by Makkar and Becker (1997b).

2. Effect of different treatments on trypsin inhibitor activity (TIA)

The effect of soaking of *J. curcas* seeds in distilled water on inactivation trypsin inhibitor was studied and data summarized in Figure (2). From the results, it could be noticed that, trypsin inhibitor activity content was decreased significantly (P<0.05) by 16.15 % and 18.97 % of defatted whole and kernel seed, respectively. This reduction may be attributed to leaching out of (TIA) as a result of soaking and also due to the known heat labile nature of trypsin inhibitors (Siddhuraju *et al*., 1996). However, the fact that not all TIA was removed showed that at least some of the trypsin inhibitors were heat-resistant. These findings agree with that reported by Magdi (2007).

The effect of germination on inactivation of trypsin inhibitor activity (TIA) in *J. curcas* seeds (Figure 2) showed that (TIA) decreased significantly (P<0.05) by 19.72 % in Jatropha kernel seeds compared with control. These results are in agreement with those reported by Magdi (2007).



	Control.	Soaking	Germination	Roasting	NaHCO3	Ethanol	E,NaHCO3	NaOH
Whole seeds	25.58	21.45	0	0.75	0.82	25.55	0.8	3.4
Kernel seeds	33.26	26.95	26.7	0.65	0.57	33.24	0.56	3.15

-All values are means of triplicate determinations ± standard deviation (SD).
-Means within rows with different letters are significantly different (P < 0.05).

Figure 2: Trypsin inhibitor activity (mg/g on dry weight basis) of *J. curcas* seeds as affected by some biolological and chemical treatments

Data also showed that trypsin inhibitor activity of Jatropha seeds reduced significantly (P<0.05) by 97.07 and 98.05 %of defatted whole Jatropha seeds and kernel, respectively due to roasting effect (Figure 2). These results are in agreement with those reported by Makkar and Becker (1997a). On the other hand, roasting of *Dolichos lablab bean* reduced the amount of trypsin inhibitor activity, by 23.05 % (Magdi, 2007).

The results given in Figure (2) showed also the effect of 0.07 % $NaHCO_3$ treatment followed by autoclaved at 121ºC for 25 min on inactivation of trypsin inhibitor activity. The results indicated that, trypsin inhibitor activity content of defatted whole Jatropha and kernel seeds were significantly decreased (P<0.05) by 96.79% and 98.29 % with whole and kernel seeds, respectively. These values were slightly better than those reported by Aderibigbe *et al*. (1997) who found that the autoclaving treatment employed inactivated the trypsin inhibitor levels by 83-99%.

Autoclaving was the most effective as trypsin inhibitors are not heat stable.

Trypsin inhibitors interfere with the physiological process of digestion through interference with the normal functioning of pancreatic proteolytic enzymes in non-ruminants, leading to severe growth depression (White *et al.*, 1989). It is possible that the antinutrient effect of trypsin inhibitors is due to their direct interaction with pancreatic proteolytic enzymes and a corresponding reduction in the digestibility of the proteins of the diet (Hajos *et al*., 1995). Trypsin inhibitors are heat-labile and can be partially or completely denatured when exposed to elevated temperature. Jyothi and Sumathi (1995) reported that the extraction at both low and high temperatures with sodium bicarbonate was most effective in the case of trypsin inhibitors of common bean seeds.

The results given in Figure (2) showed the effect of extraction of whole and kernel seed by 90 % ethanol for 2 h on inactivation of trypsin inhibitor activity. The results showed that, trypsin inhibitor activity content of defatted whole Jatropha and kernel seeds were not affected significantly (P<0.05). These results are in agreement with those reported by Chivandi *et al.* (2005).

Extraction of whole and kernel seeds by ethanol 90 % for 2 h followed by 0.07 % $NaHCO_3$ and autoclaved at 121ºC for 25 min decreased significantly (P<0.05) trypsin inhibitors values by 96.87 and 98.32% of whole and kernel Jatropha seed, respectively (Figure 2). These values were slightly better than those reported by Aderibigbe *et al*. (1997) who found that the autoclaving treatment employed inactivated the trypsin inhibitor levels by 83-99%. Autoclaving was the most effective as trypsin inhibitors are not heat stable. Trypsin inhibitors are heat-labile and can be partially or completely denatured when exposed to elevated temperature.

The effects of sodium hydroxide treatment followed by washing with distilled water on inactivation of trypsin inhibitor activity (Figure 2) showed that the trypsin inhibitor activity significantly decreased (P<0.05) by about 86.71 % and 90.53 % of defatted whole and kernel seeds, respectively. Chemical treatments (NaOH) with heat treatment for detoxification of

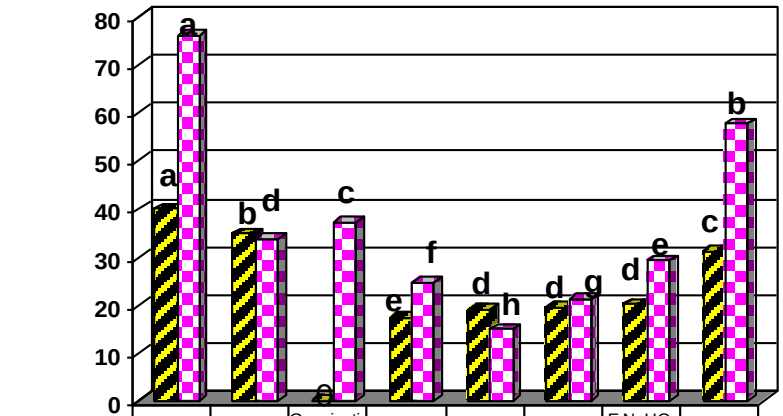
Jatropha seeds (121° C for 30 min) were most effective. These results agree with that reported by (Makkar and Becker, 1997b).

3. Effect of different treatments on total phenols

Total phenols in *J. curcas* seeds were determined after soaking in distilled water for 12 h. at room temperature and data are presented in Figure (3). The results indicate that total phenols were decreased significantly ($P<0.05$) with whole and kernel seeds, which recorded 12.72 % and 55.62 %, respectively. This reduction was attributed to leaching out of phenols into soaking water. These results are in accordance with those reported by Majed *et al*. (2006).

Total phenols level were significantly decreased ($P<0.05$) with germination of kernel seed by 50.98 % (Figure 3). This reduction may be attributed to enzymatic hydrolysis of polyphenols by polyphenol oxidase. Similar results reported by Magdi (2007).

Total phenols of *J. curcas* seeds significantly reduced ($P<0.05$) due to roasting at 160 °C/30 min and the reduction were 56.77% and 67.54 % of defatted whole and kernel seeds, respectively (Figure 3). These results are in agreement with those reported by Ibrahim *et al*. (2002).



	Control.	Soaking	Germination	Roasting	NaHCO3	Ethanol	E,NaHCO3	NaOH
Whole seeds	39.95	34.87	0	17.27	19.14	19.5	20.15	31.12
Kernel seeds	75.93	33.7	37.22	24.65	14.95	21.24	29.25	57.72

- All values are means of triplicate determinations ± standard deviation (SD).
- Means within rows with different letters are significantly different ($P < 0.05$).

Figure 3: Total phenols (mg/100g on dry weight basis) of *J. curcas* seeds as affected by some biolological and chemical treatments

The effect of 0.07 % $NaHCO_3$ treatment followed by autoclaved at 121ºC for 25 min on reduction of total phenols in defatted Jatropha seeds (Figure 3) showed that, total phenols levels were affected significantly ($P<0.05$) which reduced by 52.09% and 80.31 % with whole and kernel seeds, respectively. Similar results obtained by Vijayakumari *et al.* (1995).

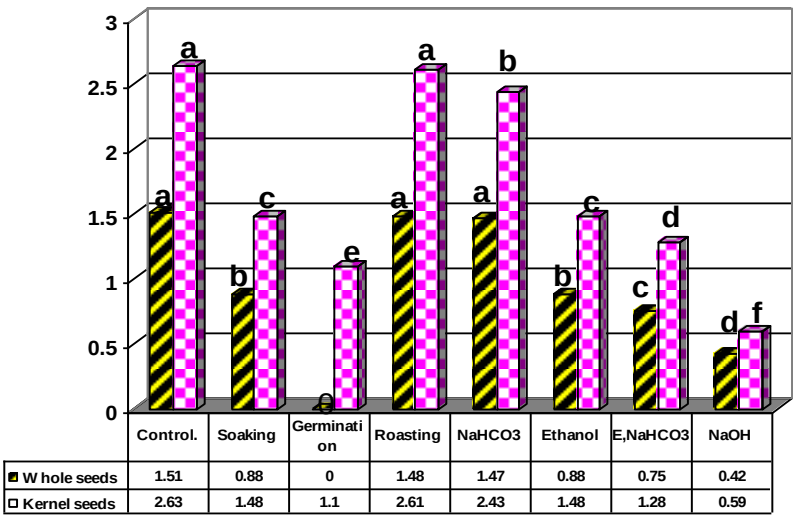
The extraction of *J. curcas* seeds by 90 % ethanol for 2 h (Figure 3).showed that, total phenols levels are reduced significantly (P<0.05) which recorded 51.19 % and 72.03 % with defatted whole and kernel seeds, respectively. This reduction of total phenols was probably due to extraction along with ethanol (Reddy and Pierson, 1994).

On the other hand, extraction of *J. curcas* seeds by 90 % ethanol for 2 h followed by 0.07 % $NaHCO_3$ and autoclaved at 121ºC/ 25 min. significantly reduced (P<0.05) total phenols in defatted whole and kernel Jatropha seeds by 49.56 % and 61.48%, respectively. Similar results reported by Vijayakumari *et al*. (1995).

The effect of sodium hydroxide (4 % solution) treatment followed by washing with distilled water on total phenols significantly reduced (P<0.05) by 22.10 % and 23.98 % in whole and kernel seeds, respectively (Figure 3). These results coincide with those detected by Stella *et al.* (1990).

4. Effect of different treatments on saponin contents

The effect of soaking defatted whole and kernel of *J. curcas* seeds in distilled water for 12 h. at room temperature (25 ±2°C) on saponins contents were studied and data shown in Figure (4). It could be noticed that the saponin contents significantly reduced (P<0.05) by 41.72 % and 43.73 % with whole and kernel seeds, respectively. This reduction could be due to leaching of saponins into the soak water. These results are in agreement with those detected by Bishnol and Khetarpaul (1994).



- All values are means of triplicate determinations ± standard deviation (SD).
- Means within rows with different letters are significantly different (P < 0.05).

Figure 4: Saponin contents (g/100g on dry weight basis) of *J. curcas* seeds as affected by some biolological and chemical treatments

Germination of *J. curcas* seeds (kernel) and their effect on saponin contents caused a significantly decrease ($P<0.05$) in saponin content of defatted kernel seeds by 58.17 % Figure (4). Similar results reported by Duhan *et al*. (2001).

Saponin contents in defatted whole and kernel seeds did not affected significantly with roasting (160 °C/30 min). These results are in agreement with those reported by Makkar *et al.* (1998).

The same Figure (4) showed the effect of $NaHCO_3$ treatment followed by autoclaved at 121ºC for 25 min. on saponin contents in *J. curcas* seeds. It could be noticed that the treatment did not affected significantly on the saponin contents in whole or kernel seeds.

The extraction of *J. curcas* seeds by 90 % ethanol for 2 h caused significant decrease ($P<0.05$) in saponin contents (Figure 4). The reduction in saponin content of defatted whole and kernel seeds of Jatropha were 41.72 % and 43.73 % with whole and kernel seeds, respectively. This reduction of saponin was probably due to extraction along with ethanol (Reddy and Pierson, 1994).

Extraction of *J. curcas* seeds by ethanol (90 %) for 2 h and 0.07 % $NaHCO_3$ as well as autoclaving at 121ºC/ 25 min on saponin contents was caused significantly decrease ($P<0.05$) in saponin content by about 50.33 % and 51.33 % of defatted whole and kernel seeds, respectively. This reduction probably due to their extraction along with ethanol. Similar results obtained by Aderibigbe *et al*. (1997) who found that the alkali treatments of Jatropha kernel seeds were most effective in reducing the saponin content by 84.2%.

Saponin content as affected by sodium hydroxide treatment of *J. curcas* seeds followed by washing by distilled water (Figure. 4) of whole and defatted kernel seeds was significantly reduced ($P<0.05$) by 72.19 % and 77.57 %, respectively. On the other hand, Makkar and Becker (1997b) reported that the alkali treatment (NaOH) with heat treatment (121° C for 30 min.) for detoxification was most effective in reducing the saponin content by 84.2 %.

Conclusion

It could be concluded that *J. curcas* seeds are source of carbohydrate, protein, oil and minerals with tolerable antinutrient level. The seed of *J. curcas* which is currently underutilized/ unexplored in most regions of the world is nutritionally promising and could solve the problem of protein malnutrition which is a major public health problem in the developing world, where diets in these parts are predominantly starchy, the major food crops being roots and tubers. The effect of some biological treatments (soaking, germination and roasting) and some chemical treatments ($NaHCO_3$, ethanol extraction and NaOH) were successful inactivating the antinutrients (phytic acid, trypsin inhibitor activity, total phenols and saponins).

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الجودة الغذائية لبذور الجاتروفا وتأثير بعض المعاملات البيولوجية والكيميائية على العوامل المضادة للتغذية

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تم دراسة الخواص الطبيعية لبذور نبات الجاتروفا المصرية فوجد أن وزن متوسط البذور الكاملة ووزن الحبة ، ووزن القشرة، والنسبة المئوية للحبة إلى البذور الكاملة ونسبة القشرة إلى البذور الكاملة كانت٠,٤٧، ٠,٦٩، ٠,٢٢ جرام ،٦٨,١٢ ٪ و ٣١,٨٨٪ على التوالي. وبدراسة التركيب الكيميائى وجد أن بذور نبات الجاتروفا هي مصدر جيد للبروتين (٣٢,٨٨ ٪) والزيت (٢٧,٣٦ ٪) والكربوهيدرات (٣٠,١١ ٪). كما أن البذور غنية في مختلف العناصر الصغرى وهى المنجنيز ، الحديد ، والزنك والتي سجلت ٢٨,٣٧، ٠,٣٨ و ٤٧,١٣ ملجم / كجم على التوالي ، فضلا عن العناصر الكبرى وهى البوتاسيوم ، الكالسيوم ، الصوديوم ، والماغنيسيوم والفوسفور والتي سجلت ١٠٣,١٣ ، ٣٤,٢١ ، ٨,٤٤ ، ١٠٩,٨٩ و ١٨٥,١٧ ملجم/ كجم على التوالي٠ كما تحتوي البذور على ٥٢,٥٩ ملجم/ ١٠٠جم و ٢٥,٥٨ ملجم/ جم و ٣٩,٩٥ ملجم/ ١٠٠جم و١,٥١ جم/ ١٠٠جم من حمض الفيتيك و مثبط نشاط التربسين والفينولات الكلية و السابونين على التوالي٠ ومن ذلك نستنتج أن بذور الجاتروفا من البذور الواعدة نظرا لارتفاع محتواها من المواد الغذائية وانخفاض محتواها من العوامل المضادة للتغذية٠ وبدراسة تأثير بعض المعاملات البيولوجية (النقع والإنبات والتحميص) و بعض المعاملات البيولوجية والكيميائية (بيكرلونات الصوديوم والإستخلاص بالإيثانول وهيدروكسيد الصوديوم) اثبتت نجاحها فى تثبيط العوامل المضادة للتغذية لبذور الجاتروفا٠

قام بتحكيم البحث

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