NUTRITIVE EVALUATION OF WATERMELON SEED (Citrullus lanatus) PARTS AND BY PRODUCTS AS RUMINANT FEED.

BY

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DEDICATION

DEDICATED TO MY FATHER AND MOTHER

MY BROTHERS AND SISTERS

ALL MY FRIENDS

Ahmad Hashim
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Render plentiful thanks and praise to most merciful Allah for giving me strength and patience to complete this study.

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Abstract

The aim of this study was to evaluate the nutritive value of watermelon seed and its different parts, pulp, hull and by-products cake. This was done by estimating the chemical composition and an in situ study of the dry matter and crude protein degradability kinetics of the seeds. Samples were collected from Western Sudan. Samples were incubated in rumen for 2, 4, 8, 16, 24, 36 and 48 hrs using two fistulated steer were fed with alfalfa.

Significant different (p<0.05) were observed in the chemical composition (DM, CP, EE, CF and ASH) of whole seed, cake, pulp and hull.

DM degradability in this study revealed that the watermelon seed cake had a lower DM degradability than whole seed and cake respectively, and had a higher (p<0.05) CP degradability followed by pulp and whole seed respectively. Therefore chemical or physical treatment were recommended to protect WMS cake protein from microbial degradation.
الخلاصة

هدفت هذه الدراسة لمعرفة التركيب الكيميائي ومعدل تكسير المادة الجافة والبروتين لبذور البطيخ الكاملة، الامباس ولب بذور البطيخ المجموعة من غرب السودان استخدم في هذه التجربة عجلين ذات ناسو كرشي وغذيت طويلة فترة التجربة على علف البرسيم.

تم تحديد مدى ومعدل تكسر المادة الجافة والبروتين عن طريق آلية أكياس الهضم. حضنت العينات كل على حدة في الكرش لمدة 2, 4, 8, 16, 24, 36 و 48 ساعة.

الاختلافات المعنوية شوهدت بين العينات الأربعة (الحبة الكاملة، الامباس، اللب والقشر) في التركيب الكيميائي للمادة الجافة، البروتين الخام، الألياف الخام، الدهن والرمام.

معدل تكسر المادة الجافة في هذه التجربة للامباس سجل أقل معدل تكسر بلب البذرة الكاملة ثم اللب على التوالي. أيضا سجل أعلى معدل تكسر للبروتين بلب البذرة الكاملة ثم اللب على التوالي.

لهذا المعاملة الكيميائية أو الفيزيائية ضرورية لحماية بروتين امباس حب البطيخ من ميكروبات الكرش.
INTRODUCTION

Protein and energy are considered basic feed components, that add to the abnormally high cost of concentrate of ruminant feed, because of the continuous increase in their price. Protein supplement are integrad component of animal diets, are needed to increase the total quantity of protein as well as satisfy to essential amino acid requirement.

Protein can be further described by rumen solubility and degradation. Solubility is the amount of protein going into solution in rumen fluid. Solubility is determined by mixing a weighed sample with a known volume of rumen fluid.

Water melon seeds are byproduct obtained after feeding the melon fruits to animals as a source of water.

Watermelon seed are one of many common protein supplements such as cotton seed, soybean meal, and rapeseed. There are different types or slightly different characteristic of watermelon seed carrying the same ices.

Watermelon seed are cultivated in large quantities in Western Sudan. They can be used as a non – conventional ruminant feed because of their availability, low cost and not used by human.
The main objective:

The main objective of this study was to evaluate nutritive value and the degradability parameters of crude protein and dry matter in whole, cake and pulp of watermelon seed.
2.1. what is the watermelon

Botanically, watermelon is named (Citrullus lanatus) and it belongs to the family cucurbitaceae. (Rice et al. 1987). The Sudan is considered as the country of origin for watermelon, especially, Kordufan zone where it grows as a wild plant (Gokovsky, 1971). Sweet watermelon has many local names in Middle East countries such as (battikh) in Sudan, (Hub–Hub) in Saudi Arabia.

Watermelon fruits include numerous flattened seeds constituting about 1.9–4% of fresh fruit (Kamel et al. 1985). Seeds are contained in the pulp. Seeds of different varieties vary in size, thickness, texture of the seeds coat and the thickness of the seeds edges. There are small, moderate and large sized seeds. The seeds differ in colour, they may be black, brown, red, yellow or rarely white (Oyolu, 1977). Watermelon seeds length and width may be about (0.6 – 1.5cm) and (0.5 – 0.7cm) respectively.

2.2 Utilization of watermelon:

Watermelon, especially, the desert type may remain fresh until the start of the next rainy season, thus constituting a perennial source of water. This advantage advocates its use as a main source of water for livestock.
Watermelon seed protein was suggested to be the useful as feed additives and extenders because of their high capacity to pend fat (Gbenle and Onyekachi, 1995).

Watermelon seeds oil is extracted and its oil is used for cooking, for medicinal purposes or soap making and sometime for illumination (ElMagoli et al, 1979, Bedi and at al, 1971). In addition watermelon seed oil has advantage of containing low amount of saturated fatty acids which can benefit patients with cardiovascular disease. (Al-Khalifa, 1996 and Girgis and Said, 1968).

2.3 Kordufan watermelon:

Kordufan watermelon was transported from El Obied market to the Food Research Centre about six months after harvest time. The Fruits were divided according to rind color into three types, streak ad whitish – yellow and mosaiced. Color of the flesh ranged between white, light pink and white with pinkish patches. Flesh was firmer but lacked the favor and crispness of desert watermelon. Seed content of the fruit was more than 4 per cent of the total weight of the fruit. PH, acidity, total soluble solid and total sugars were almost similar to the desert varieties purchased from Kordofan market. Watermelon was generally richer in ascorbic acid compared to the desert varieties. Sugar present in the melon were inverted sugars. (Saeed and Abdalla1973).
2.4 Watermelon seed cake:

Watermelon and its by-products have found a wide range of use as edible products. The seeds of the wild variety of watermelon can be used for animal feeding after the extraction of the oil (Krishnan and Krishnaswamy 1939) have reported the high content of urease in watermelon seed. The oil content of the seed is found to vary to a great extent depending upon the place of origin as reported by Dhingra and Biswas (1945). Bijada cake forms a good source of digestible protein.

The cake can be compared with coconut, cotton and linseed cake and with Matri, Moth, Rawan and Serson seed as given by Sem (1925). The cake can be fed to animals safely and no adverse effects have been noticed, and gave a good account of its medicinal use. Considering all this, the cake can be safely fed to animals.

2.5 Nutritional value of watermelon seed cake:

Studies of animal nutrition centre in India (1965 -1966) and Pal and Mahdevan (1968) indicated that watermelon seed cake is a good source of protein for animal and it is comparable to cotton seed cake, linseed cake, neem seed cake and sarson cake.
2.6 Feeding value of watermelon seed for cattle:

Pal and Mahdevan (1968) examined the incorporation of watermelon seed cake in feed of kumoani bullocks. He found that when 1 kg of watermelon seed cake as concentrate was offered daily during 13 days trial period, no residual was left in the first 7 days, but from the 8th days onwards the animal started leaving residue which rose up to 880 gm per day when only one kilogram of watermelon seed concentrate was offered. When watermelon seed was mixed with barely at ratio of 3:1 the residue left during the trial was to the extent of 42% of the total ratio. When increasing the barely proportion in the ratio 1:1 the residue left was reduced to the extent of 20% of whole concentrate.

Though watermelon seed cake was not highly palatable, animal can be induced to eat the same with barely, also addition of common salt was found to increase the palatability of watermelon seed cake.

The formerly mentioned workers also found that, the digestible crude protein content in watermelon seed cake is 20% and proved to be a good of digestible crude protein and total digestible nutrient in kg per 100 kg were found to be 20.42 and 52.73 respectively and they concluded that, watermelon seed cake can form a good cattle feed. In another work Singh et al (1973) reported that watermelon seed cake can safely be fed to cattle up to 20% level.
2.7 What is the nylon bag technique?

The nylon bag technique is a simple means of obtaining estimates of potential degradability of supplements and feed stuff for ruminants. Rate of disappearance of test material from the bags is particularly sensitive to the basal diet or the cannulated animal inclusion of values for fractional clearance of un digested food residues from the rumen into calculation of degradability provides estimates of rate of degradation of the various component of the test material which more closely approximate true degradability of the material in the rumen. Several method are used to estimate ruminal degradation of DM and CP (Hvelplund and Weisbjerg, 1998).The in situ method has achieved the widest use. Therefore, the in situ technique has been chosen as the reference method to measure rumen CP degradation in several protein evaluations System for ruminant (Madsen, 1985; Verite and Peyraud, 1989; Tamminga et al., 1994).

2.8 The uses of the nylon bag technique:

The nylon bag technique has been used for many years to provide estimates of the rate and extent of disappearance of feed constituents from the rumen (Quin et al 1938; Rodriguez 1968; Mehrez &Orskov 1977). Under certain dietary and production condition, ruminant diets must be supplemented with forms of rumen non-degraded dietary protein (by bass protein) to increase the efficiency of nutrient utilization and hence production (Kempton
et al 1977). Thus there is need for a technique to quantify the potential degradability in the rumen of commercially available supplements. Although accuracy of the technique is influenced by certain factors, it provides a relatively simple means of grading supplements in term of potential degradability.

2.9 Proximate chemical composition of water melon seed:

2.9.1 Moisture content:

Al Khalifa (1996) reported that the moisture content of water melon seeds from different places are as to be 2.61 for an Egyptian watermelon seeds, 3.14 for an Iranian and 3.24 for Chinese water melon seeds .In another study Shayo, (1992) reported that the moisture content of whole watermelon seed was 4.5%. Yousuf (1992) showed that, the moisture content of Sudanese watermelon seeds special type obtained from western Sudan is 2.8%, where as Mustafa et al (1975) reported 4.94% for another type obtained from kordufan in the vicinity of Elobied . Hayat (1994) found 3.45% moisture content in water melon seeds. Ogunsua et al (1984) reported the moisture content of two Nigerian varieties of water melon seeds to be 7.9% and 5.6% respectively.

2.9.2 Crude protein:
The value of cucurbit seeds including watermelon as source of proteins as well as oil in animal diets has been reviewed by Bemis et al (1967 and 1975).

Mustafa et al (1972) reported that the crude protein content of a whole watermelon seed is 18.96%. The CP content of whole watermelon seed was 16.5%. whereas Dawson (1985); Asil et al (1985) and Rakhimove et al (1995) showed crude protein content range of whole watermelon seeds between 13.5% and 16.4% which is contrary as finding of Purseglove (1968) that reached to a range of 25-32% kernel of watermelon seeds, as reported by Al khalifa (1995), contained about 40.5%, 24.55 and 39% crude protein for an Egyptian, Iranian and Chinese varieties, respectively. Ogunsua et al. (1984) showed crude protein range of dehulled watermelon seed from Oyo state in Nigeria between 30.8 and 34%.

Approximately similar results were obtained for the crude protein content in watermelon seed kernel by FAO (1988) and Hayat (1994). Mustafa et al. (1972) reported that, the crude protein content in the seed kernel is 39.1%, whereas Asil (1968) reported a range between 25% and 32%, which came in accord with the finding of Akobundu et al. (1982). Concerning the crude protein content in the hull, Mustafa et al. (1972) reported only 0.52%, whereas Hayat (1994) reported 2.5%. Western regional animal nutrition centre of Africa (1965-1966) reported arrange of
19.1- 25.1% crude protein in the watermelon seed cake, where as Nwokolo and Sim (1987) showed that, the crude protein content in the pressed melon seed cake is 45.33% with respect to protein content in the defatted melon seed meal the same workers reported 66.2%. Moreover, Oyenuga and Fetuga (1974) showed the crude protein of the defatted meal to be between 69.4% and 77.7%. Gbenle and Onyeka (1995) reported the crude protein content of the defatted flour and protein isolate of watermelon seed to be 62.7% and 75% respectively. Almost similar results were obtained by Abaelu et al. (1979).

2.9.3 Ether Extract:

Oil content of many Sudanese varieties of whole ground watermelon seed is in the range of 25.8 to 28.7% (Mustafa et al. 1972). Shayo, (1992) reported that the EE content of whole watermelon seed was 23.5%. In another study, Nwokolo and Sim (1987) reported 49.6% oil content in whole seed. Moreover, Girgis and Said (1968) reported that, the oil content in whole ground watermelon seed of “Egusi” and another variety “Cuban queen” from Florida are 51% and 26.5%, respectively. Adversely, low content of oil in whole seeds of “Egusi” watermelon type of 23.1% and 26.6% were reported by Kamel et al. (1985) and Daghir et al. (1986), respectively. With respect to the oil content in seed kernel, Ogunsua et al. (1984) found that the oil content of two varieties of dehulled watermelon
seed to be 47.7% and 51.1%, respectively, whereas Oyenuga and Fetuga (1975) reported that the content of dehulled raw undefeated watermelon seed meal is 54.2% and that of the dehulled fried undefeated watermelon seed meal is 53.7%. Approximately, similar results were obtained by Asil (1985) and Hayat (1994 which were in the range of 50.36 and 51.4%. With range to oil content of hull, Mustafa (1972) found 0.78% whereas Hayat (1994) reported 2.738%. The noticeable variation in oil contents may be attributed to varietals differences, source of seed and climatic and growing condition.

2.9.4 Crude fiber content:

Kamel et al., (1985) reported that, the fiber content of whole watermelon seed on dry matter bases to be 47.7% it was also reported that the fiber content of whole watermelon seed is about 37.7% (Mustafa et al., (1972). In another study the CF content of whole watermelon seed was 39%. The same workers declared the fiber content in kernel to be 4.17% where as Ogunuga and Fetuga, (1975) and Al-Khalifa et al., (1996) found that a range of 2.4% and 6.14%. Mustafa et al., (1972) reported the fiber content of the seed hull to be 76.18% where as Hayat, (1994) reported 72.3%. These high levels of crude fiber content in both of watermelon seeds and meal may interfere with their levels of inclusion in broiler ration since; nutritionally permissible level of fiber in broiler should not exceed 8%.

2.9.5 The total ash in watermelon seed:
Ash content of watermelon seeds was investigated by several workers, Mustafa et al., (1972); Ogunsua et al., (1984); Lasztity et al., (1986); Hayat (1994); Shoay et al (1992), and Al khalifa, (1996) and it was found in range of 1.85-5.2%.

2.9.6 Carbohydrate content:

With respect to the carbohydrate content of watermelon seed Al khalifa (1996) reported a range in watermelon seed from different places between 23.4% and 45.1% conversely the result is obtained by Mustafa ., (1972); Ouenuga and Fetuga , (1975) and Ogumsua, (1984) in which the range of carbohydrate content is only 3.50 % - 8.38%.

These results approximately comparable to those obtained for an (Egusi) water melon seeds which contain between 2 and 6.13% Oyolu (1977) and Sawaya et al (1986). In addition Mustafa et al (1972) reported the carbohydrate content of the whole seeds and hull to be 8.38% and 1.5% respectively.

2.10 Dry matter degradability of feed stuff:

There was a large variation between feed stuff in dry matter degradability and disappearance. Sampath et al, (1985) reported the DM disappearance of groundnut cake and coconut cake in 3-24 (h) was 25 and 10 respectively. Another study, Hadjipanayiotou and Economides (2001) who estimate parameters of DM disappearance of soybean meal and
sunflower seed reported there was 30.27 and 22.09, 66.95 and 42.61, 0.04 and 0.08, 54.63 and 43.77 respectively for (a, b, c and ED in 0.08). Sibanda et al (1993) reported the DM water soluble fraction was 20.2 % for cotton seed cake. Also reported values of the a fraction and c rate of dry matter was 19.6 and 0.05 when cotton seed cake was incubated with maze. Tona et al (2003) reported a degradation rate of 0.035 when combination of cotton seed cake, dried brewers and lablab hay was used. Odeyinka et al (2004) found the DM degradable fraction of some tropical seed ranged between 7.12-11.5 %. Gralak et al (1997) reported the ED dry matter degradability of soybean meal, canola seed and peanut 72.2, 74.1 and 85.9 respectively. Olisen et al (2003) found the DM water solubility % of soy meal, rape seed meal, rape seed and guar meal was 30.1, 21.2, 11.7 and 28.2, wash fraction % was 31.1, 30.3, 17.4 and 27.9, and ED was 68.7, 65.8, 53.7 and 74.4 respectively. Asaad (2006) reported DM degradability parameters of seasem cake was 25, 71.9, 0.059, 80.2, 66.2 and 58.4 for (a, b, c, ED in 0.02, 0.05 and 0.08 rumen out flow rate) respectively.

Promkot et al (2003) reported the DM disappearance and degradability parameters (a, b, c, a+b and ED) of cotton seed meal and soybean meal 22.8 and 24.2, 39.7 and 60.6, 0.058 and 0.068, 62.4 and 84.7, 41.9 and 56.12 respectively. The DM disappearance of watermelon seed and sunflower seed cake in 6-24 (h) was 39.2-44.7 and 37.6-47.2 respectively.
(Shayo (1992). The water in soluble fraction (b) for DM of some tropical seed in range of 7.12-11.5 % (Odeyinka et al (2004)).

2.11 Crude protein degradability of feed stuff:

There can be a wide variation in protein degradation of feed stuff. Hadjipanayiotou et al (2001) reported the soybean meal protein is relatively degradable protein, where for a, b, c, and ED at in 0.08 rumen out flow rate of soybean meal and sunflower seed was 13.38 and 22.7, 44.43 and 22.73, 0.02 and 0.01, 37.80 and 61.87 respectively. Sibanda et al (1993) reported the CP water soluble fraction of cotton seed cake was 9.8 %. Tona et al reported ranged between 6.49-11.11 when cotton seed cake combination with dried brewers and lablab hay. Sampath et al (1985) found that the CP disappearance in 3-24 of groundnut cake and coconut cake was 28-44% and 3-38 % respectively also estimates the ED of CP in 0.05 rumen out flow rate was 66.8 and 19.1 respectively. Gralak et al (1997) reported that CP degradability of soybean, canola seed and peanut 71.9, 66.8 and 70.8% respectively. Olaisen et al (2003) found that the CP water solubility of soy meal, rapeseed meal, rapeseed and guar meal was 6.3, 12.8, 15.6 and 8.1 respectively, and the in situ CP wash fraction was 13.9, 29.7, 21.4 and 13.3 respectively, and the ED of CP was 62.7, 71.6, 63 and 68.3 respectively. Sibanda et al (1993) reported the CP degradable fraction and potential degradability and degradation rate of cotton seed cake was 72.90, 82.7 and 0.05 respectively. The CP potential degradability and degradation
rate was ranged between 88.36-94.30 and 0.02 0.03 respectively (Tona et al 2003) when combination of cotton seed cake, dried brewers and lablab hay. Promkot et al (2003) reported that the CP disappearance and degradability parameters (a, b, c, a+b and ED) of cotton seed meal and soybean meal was 31 and 15.1, 40.5 and 72.7, 0.043 and 0.078, 71.5 and 87.8, 49.6 and 59.2 respectively.
CHAPTER THREE

MATERIALS AND METHODS

3.1 Collection of samples:
Rain fed grown watermelon Seed sample were collected from western Sudan. The Seeds were cleaned and sun dried in shallow trays and stored in polythene bags until being analyzed.

3.1.1 Preparation of samples:
Watermelon seeds are separated into 4 categories: Whole seeds, Cake, Pulp, and hull. The pulp and hull were removed manually before grinding. The oil was extracted from the whole seed and the residue was the cake. Samples were prepared by grinding through laboratory hammer mill with a 205 mm screen.

3.1.2 Proximate analysis:
Proximate analysis for chemical components dry matter (DM), crude protein (CP), crude fiber (CF), Ash and ether extract (EE) was determined according to AOAC (1980).
3.2 The degradability study

Nylon bags size 5 6 cm were used for the incubation of the samples, according to the method adopted by (Ørskov, 1991). The empty bags were first washed, oven dried at 60° C for over night then individually weighed and their weights were recorded. 5 grams of each part were weighed into a nylon bag tied with a nylon ribbon and introduced, using a plastic tube of 20-25cm length, above the fistula level to ease the movement of the bag inside the rumen.

The bags (2 bags/bull/period) were incubated for different periods of time i.e. 2, 4, 8, 16, 24, 36 and 48 hours for each part.

The bags were immediately removed at the end of each incubation period then thoroughly washed under running tap water. Residues in the bags were oven dried at 60° C for overnight. Then taken out, cooled in desiccators and after that weighed.

The percentage of dry matter loss was calculated as follows:

\[
\text{DM disappearance}\% = \frac{(\text{Wt. of incubated sample} - \text{wt. of residue after incubation})}{\text{Wt. of incubated sample}} \times 100
\]

\[
\text{CP disappearance}\% = \frac{(\text{CP\% of incubated sample} - \text{CP \% of residue after incubation})}{\text{CP \% of incubated sample}} \times 100
\]
Degradation at zero time was estimated by weighing 3 grams of each part inside the nylon bag washed under running tap water without rumen incubation the dry matter loss percentage which is the soluble fraction (a) was determined as follows:

\[
\frac{(\text{Wt. of sample} - \text{wt. of residue after washing})}{\text{Wt. of sample}} \times 100
\]

\[P = a + b \left(1 - \exp^{-ct}\right)\]

Where:

P = potential degradability.

t = incubation time.

a = axis intercept at time zero present soluble and completely degradable substrate that is rapidly washed out of the bag.

b = the difference between intercept (a) and the asymptote percentage the insoluble but potentially degradable substrate, which is degraded by the microorganisms according to first order kinetics.

c = rate constant.

a, b and c are constant fitted by interactive least squares procedure.

McDonald, (1981) equation provides curve constant that can be used in conjunction with predicated values after rates for specified diets to estimate the potential degradability:

Potential degradability = \(a + \frac{bc}{C+k}\)

Where:
a, b and c are constant.

k = rumen out flow rate.

Then a graph was plotted by observed values of dry matter disappearance percentage against time of incubation in hours to form a curve.

A computer program was used to draw the graph, which represent the DM degradability rate and to calculate the potential degradability.

3.3 Statistical analysis used:

The experiment was conducted following the Completely Randomize Design (C.R.D). The data were subjected to analysis of variance and regression analysis according to Steel, et al; 1997.). Computer program (Means) were compared using Least Significant Different (LSD).
CHAPTER FOUR

RESULTS

4.1 The chemical composition:

The chemical composition of whole, cake, pulp and hull of watermelon seed were shown in table (1).

The dry matter of whole, cake, pulp and hull of watermelon seed it was 90.08, 95.55, 98.12 and 97.36 respectively. The highest(p<0.05) DM was shown by pulp and lowest value found by cake.

The higher (p<0.05) value of CP content was found in the pulp 33.20, and the lowest value recorded by whole seeds.

The crude fiber of hull record the highest (p<0.05) amount was (73.47), and the low amount found by pulp.

The pulp EE content (45.38) was significantly(p<0.05) higher when compared with other parts, and the lowest value was in the hull.

The ash content of pulp seed recorded the lowest amount it was 1.43, closely followed by cake.
Table (1)
The chemical composition of whole seed, cake, pulp and hull of watermelon seed % on dry matter basis.

<table>
<thead>
<tr>
<th></th>
<th>CP</th>
<th>CF</th>
<th>EE</th>
<th>ASH</th>
<th>DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHOLE SEED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>20.87</td>
<td>38.39</td>
<td>30.13</td>
<td>4.23</td>
<td>96.08</td>
</tr>
<tr>
<td>DM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAKE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>25.39</td>
<td>27.39</td>
<td>7.84</td>
<td>2.70</td>
<td>95.55</td>
</tr>
<tr>
<td>DM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PULP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>33.20</td>
<td>5.42</td>
<td>45.39</td>
<td>1.43</td>
<td>98.12</td>
</tr>
<tr>
<td>DM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HULL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>8.37</td>
<td>73.47</td>
<td>3.33</td>
<td>5.47</td>
<td>97.36</td>
</tr>
<tr>
<td>DM</td>
<td>0.219</td>
<td>0.319</td>
<td>0.686</td>
<td>0.189</td>
<td>0.161</td>
</tr>
</tbody>
</table>

$a,b,c,d$ Means in the same column with different superscripts differ significantly ($P < 0.05$)

DM = Dry matter, CP = Crude protein, CF = Crude fibre, EE = Ether extract
4.2 Dry matter degradability:

Mean proportion of dry matter disappearance from whole seed, cake and pulp of watermelon seed at different period of incubation in the rumen are shown in table (2) and graphically in figure (1).

It can be seen from table (2) that at each time intervals the proportion of dry matter disappearing from whole seed and cake was slightly lower than values for pulp.

4.3 Crude protein degradation:

Mean proportion of crude protein disappearing from whole seed, cake and pulp of watermelon seed at various periods of incubation (h) in the rumen are shown in table (3) and graphically in figure (3).

The proportion of CP disappearing from whole seed and cake are higher than the values from pulp especially in the first periods (2, 4, 8, 16, 24) and there was a linear increase in the protein disappearance of pulp with increase in the period of incubation in the rumen to 48 h than whole seed and cake.
Table (2)

**Rumen degradation of dry matter of whole seed, cake and pulp of watermelon seed.**

<table>
<thead>
<tr>
<th></th>
<th>2 h</th>
<th>4 h</th>
<th>8 h</th>
<th>16 h</th>
<th>24 h</th>
<th>36 h</th>
<th>48 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHOLE SEED%</td>
<td>49.33%</td>
<td>50.78%</td>
<td>53.35%</td>
<td>57.4%</td>
<td>60.5%</td>
<td>64.08%</td>
<td>66.75%</td>
</tr>
<tr>
<td>CAKE%</td>
<td>39.75%</td>
<td>40.58%</td>
<td>42.2%</td>
<td>45.2%</td>
<td>47.88%</td>
<td>51.45%</td>
<td>54.58%</td>
</tr>
<tr>
<td>PULP%</td>
<td>67.18%</td>
<td>71.05%</td>
<td>77.58%</td>
<td>86.75%</td>
<td>92.5%</td>
<td>97.35%</td>
<td>99.8%</td>
</tr>
</tbody>
</table>

Table (3)

**Rumen degradation of crude protein of whole seed, cake and pulp of watermelon seed.**

<table>
<thead>
<tr>
<th></th>
<th>2 h</th>
<th>4 h</th>
<th>8 h</th>
<th>16 h</th>
<th>24 h</th>
<th>36 h</th>
<th>48 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHOLE SEED%</td>
<td>82.6%</td>
<td>84.85%</td>
<td>89.2%</td>
<td>91.38%</td>
<td>93.63%</td>
<td>96.05%</td>
<td>97.93%</td>
</tr>
<tr>
<td>CAKE%</td>
<td>81.65%</td>
<td>82.18%</td>
<td>83.93%</td>
<td>86.48%</td>
<td>89.85%</td>
<td>91.25%</td>
<td>93.38%</td>
</tr>
<tr>
<td>PULP%</td>
<td>70.95%</td>
<td>74.5%</td>
<td>80.43%</td>
<td>87.05%</td>
<td>93.7%</td>
<td>97.88%</td>
<td>99.9%</td>
</tr>
</tbody>
</table>
Disappearance of dry matter in sacco rumen of whole seed, cake and pulp of watermelon seed over time.
Figure (2):

Disappearance of crude protein in sacco rumen of whole seed, cake and pulp of watermelon seed over time.
4.4 The degradation kinetics of dry matter:

The degradation kinetics of dry matter in whole, cake and pulp seed of watermelon was shown in table (4). The pulp was significantly (p<0.05) more soluble in water soluble fraction (a) 62.83, while the cake sample showed the lowest value 38.88. The degradable fraction (b) was higher(p<0.05) in WMS cake 43.70 then the other parts and the lowest values in whole seed. The lower degradation rate (c) at time t was founded in watermelon seed cake it was 0.012 and the lower value was recorded by whole seeds. The potential degradability (a+b) the pulp exhibition the highest (p<0.05) value 105.85 , and lower amount found by cake. Effective degradability of cake DM was low at the 3 levels of rumen out flow rate it was 56.95, 49.14 and 46.5 at (0.02, 0.05 and 0.08) respectively. The highest (p<0.05) value was recorded by pulp.
Table (4)
Degradation kinetics of DM of whole seed, cake and pulp of watermelon seed %.

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>a+b</th>
<th>c</th>
<th>ED 0.02</th>
<th>ED 0.05</th>
<th>ED 0.08</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHOLE SEED</td>
<td>47.725</td>
<td>33.475</td>
<td>81.200</td>
<td>0.0310</td>
<td>59.950</td>
<td>54.050</td>
<td>61.750</td>
</tr>
<tr>
<td>CAKE</td>
<td>38.875</td>
<td>43.700</td>
<td>82.550</td>
<td>0.0115</td>
<td>56.950</td>
<td>49.125</td>
<td>46.500</td>
</tr>
<tr>
<td>PULP</td>
<td>62.825</td>
<td>39.525</td>
<td>104.85</td>
<td>0.0588</td>
<td>92.200</td>
<td>84.125</td>
<td>79.525</td>
</tr>
<tr>
<td>SE of MEAN</td>
<td>1.1511</td>
<td>9.6159</td>
<td>10.039</td>
<td>0.0103</td>
<td>0.7204</td>
<td>2.4600</td>
<td>4.6276</td>
</tr>
</tbody>
</table>

\(a,b,c,ab\) Means in the same column with different superscripts differ significantly (\(P < 0.05\)).

a water soluble fraction
b water insoluble fraction
a+b potential degradability
c the rate of degradation
ED the effective degradability at three levels of rumen out flow rate 0.02 & 0.05 & 0.08
4.5 The degradation kinetics of crude protein:
In this study the degradation kinetics of CP of whole seed, cake and pulp of watermelon seed was shown in table (5).

The lowest water soluble fraction results of CP was observed in pulp it was 68.40, and lowest value was recorded by pulp.

The degradable fraction of crude proteins was observed lowest amount in cake 17.20, followed by pulp.

Pulp found the highest (p<0.05) degradation rate was 0.061, followed by cake.

The potential degradability (a+b) of cake reported the lowest value 99.37, followed by WMS pulp.

Effective degradability of pulp was lower in 2 level of rumen out flow rate it was 86.7 and 82.97 at (0.05 and 0.08) respectively followed by cake. Where the cake record the highest (p<0.05) value CP effective degradability in 0.02 level it was 91.9.

Table (5)
The Degradation kinetics of CP of whole seed,
cake and pulp of watermelon seed %

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>a+b</th>
<th>c</th>
<th>ED 0.02</th>
<th>ED 0.05</th>
<th>ED 0.08</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In this study the moisture content of whole seed was 3.92 %.

This result is similar to that obtained by Hayat (1994); and Alkhalifa (1972), who reported the moisture content of whole WMS range 3.14-3.45 %. This result is lower than that obtained by Ogunsua (1984) who found a moisture content...
obtained by Yousuf (1992) 2content range of 5.6 and 7.9 %, and higher than 2.8 %. obtained by Yousuf (1992).

The moisture content of WMS cake, pulp and hull was 4.45 %, 1.88 % and 2.64 % respectively.

The CP content of whole seed in this study was 20.87 %. This is in agreement with finding of Mustafa (1972). This result were higher than that obtained by Dawson (1985); Asil (1985) and Rakhimove (1995) who showed in CP WMS content of 13.5-16.4 %. The CP content of WMS cake was 25.39 %, similar to that obtained by Westren Regrition Animal Nutrition Centre of Africa (1965-1966) who reported a range of 19.1-25.1 % CP in WMS cake.

In this study the results showed that the WMS pulp had a relatively higher protein content. This is in consistent with result obtained by Alkhalifa (1996); Ogunsua (1984); FAO (1988); Hayat (1994) and Mustafa (1972).

The value of CP content of WMS hull in this study was 8.37 %. This finding is higher than that obtained by Mustafa (1972) who reported (5.2 %), where as Hayat (1994) reported 2.5 % CP in WMS hull.

The oil content of whole seed WMS in this study was 30.13 %, this result is inconsistent with, Shayo (1992) who reported a ranged of 23.5-28.7 %, and lower than Nwokolo and Sim (1987) reported 49.6 % oil content in WMS. EE of WMS cake in this study was 7.8 %. The WMS pulp in this study resulted has high EE value (45.38%) than whole seed and cake.
Approximately similar results were obtained by Ogunsua (1984) who found that the oil content of two variates of dehulled WMS was 47.7 %. The EE observed in WMS hull was 3.33 % to some extent similar to that obtained by Hayat (1994) found 2.74 %, and higher than Mustafa (1972) found 0.78 %. The CF content in WMS in this study (38.39 %) similar to that obtained by Mustafa (1972) who found that the fiber content of whole WMS is about 37.7 %, and lower than finding of Kamel (1985) who found 47.7 % fiber content of whole WMS in dry matter bases.

The lowest CF content was observed in WMS pulp (5.42 %) this agree with results of Alkhalifa (1996) who found a range of 2.4 and 6.14 %. The CF of WMS hull was (73.47%) this finding was supports that the finding of Hayat (1994) who reported 72.3 %.

The ash content of whole WMS in this study was 4.23 %. This result is in line with the range of 1.85-5.2 % obtained by Ogunsua (1984); Lasztity (1986); Hayat (1994); Shayo (1992) and Alkhalifa (1996).

Based on the results of proximate analysis of chemical composition of watermelon seed and by products, there are different between this results and results obtained by different worker. This variation may be ascribed to many factors. These factors are, climate, soil, variety, variation in seed components, cultivation method, harvesting time, the type of irrigation, growing condition and the amount of rain falls during the growing.
The values of DM water soluble fraction (a) in this study was (47.72, 38.88 and 62.38) for whole seed, cake and pulp respectively was higher than (a) value of 20.2 % reported by Sibanda et al (1993) for dry matter of cotton seed cake and (a) value of 19.6 % obtained when cotton seed cake was incubated in combination with maize. Also higher than (a) value of soybean meal and sunflower seed was 30.27 and 22.09 obtained by Hadjipanayiotou and Economides (2001).

The DM degradable fraction (b) values obtained in this study was (33.48, 43.7 and 39.53) for whole seed, cake and pulp respectively, were higher than that values of 7.12 and 11.5 for some tropical seed reported by Odeyinka et al (2004).These values were lower than that obtained by Hadjipanayiotou and Economides (2001) who found the degradable fraction of soybean meal and sunflower seed to be 66.5 and 42.61 respectively.

The rate of DM degradation (c) values in this study was (0.03, 0.01 and 0.06) for whole seed, cake and pulp respectively, similar to that obtained by Hadjipanayiotou and Economides (2001) who reported 0.04 and 0.08 degradation rate of soybean meal and sunflower seed. However these results were higher than 0.053 reported by Sibanda et al (1993) of degradation rate of cotton seed cake, and higher than that 0.035 obtained by Tona et al (2003) when incubated a combination of cotton seed cake, dried brewers and lablab hay.
In this study the potential degradability (PD) of DM values was (81.20, 82.55 and 104.85 %) for whole seed, cake and pulp respectively, which higher than that obtained by Promkot et al (2003) who found a dry matter potential degradability for cotton seed meal and soybean meal 84.7 and 41.9 % respectively.

In this study the values of DM effective degradability (ED) at rumen out flow rate (0.02, 0.05 and 0.08) for WMS cake was 56.95, 49.12 and 46.5 % respectively. These values were close to that obtained by Promkot et al (2003) who found the ED of DM of cotton seed meal and soybean meal at 0.05 rumen out flow rate were 41.9 and 56.12 respectively. These results were lower than that obtained by Asaad (2006) who reported the DM effective degradability at three levels of rumen out flow rate of sesame cake was 80.2, 66.2 and 58.4 %. Higher DM effective degradability were obtained by Gralak (1997) for soybean meal, canola seed and peanut at 0.05 rumen out flow rate 72.2, 74.1 and 85.9 % respectively.

The values of CP water soluble fraction obtained in this study of whole seed, cake and pulp were (79.23, 82.17 and 68.4 %) and degradation rate c were (0.1, 0.03 and 0.01 %) for whole seed, cake and pulp respectively. These results were higher than that obtained by Sibanda et al (1993) who reported the water soluble fraction of cotton seed cake was 9.8 %. and higher than that obtained by Tona et al (2003) who reported that the water soluble fraction and degradation rate of combination cotton seed cake, dried brewers
and lablab hay were ranged between 6.49-11.11 and 0.02-0.03 % respectively.

The degradable fraction b values of CP were (34.6, 17.2 and 33.07 %) for whole seed, cake and pulp respectively. These results were lower than value of 72.9 % reported by Sibanda et al (1993) for cotton seed cake.

The CP potential degradability in this study was (113.83, 99.37 and 101.47 %) for whole seed, cake and pulp respectively. These results were higher than that obtained by Sibanda et al (1993) who reported the potential degradability of cotton seed cake was 82.7 % and similar to that obtained by Asaad (2006) who reported the CP potential degradability of sesame cake 100 %.

The value of CP effective degradability at 0.08 rumen out flow rate in this study of whole seed, cake and pulp was (88.133, 86.46 and 82.96). The soluble fraction a, and degradation rate (c) of WMS cake respectively, protein was 82.167 % and 0.03 % respectively. These values were higher than that reported by Asaad (2006) who found the soluble fraction (a) and degradation rate (c) of sesame cake was 66.1 % and 0.02 % respectively.
**Conclusion and recommendation**

The watermelon seed cake is a very good source of protein supplement.

The CP of watermelon seed cake and pulp were highly degradable.

Therefore I recommend to use the chemical or physical treatment to protect WMS cake protein from microbial degradation.
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