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A comparative study on weight changes in rats fed with diet containing *Yaji*, *Yaji*-additives and *Yaji*-spices

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Abstract
This eight-week study investigates the effect of *Yaji* on the weight of adult Wister rats. The experimental rats were subdivided into nine groups (A – I). Group A (control) received 300g of feed (growers mash) only; B received 237g of feed plus 9g of each of the combined constituents of *Yaji,* while C, D, E, F, G, H and I, received 291g of feed plus 9g of clove, salt, MSG, ginger, red pepper, black pepper, and groundnut respectively. At the end of each week, the weights of 3 randomly selected rats were taken and the mean recorded. The overall results showed that there was weight gain in groups D, E and I as compared to A, while weight loss was observed in groups B, C, F, G and H. Although these changes were not statistically significant, it suggests however, that *Yaji* has inherent potentials for weight management, in so far as its production and consumption is regulated.

Keywords: Nutrition; obesity; weight; *Yaji*; spices; additives; fat deposition.

Introduction

Fat deposition has been seen as a defensive mechanism that enables the storage of energy thereby increasing the chances of survival during times of food scarcity (Keith, 2007). However, many health complications has been attributed to fat storage and abnormal weight gain which, according to Barness *et al.* (2007), Kopelman and Caterson (2005) and WHO (2000), is reported to be a leading preventable cause of death worldwide with increasing prevalence in adults and children and increasingly negative impact on healthcare systems. Authorities view it as one of the most serious public health problems of the 21st century.

Furthermore, obesity is known to be a major factor for a number of co-morbidities such as coronary heart diseases, noninsulin-dependent diabetes mellitus, pulmonary dysfunction, osteoarthritis and certain types of cancer (Haslam and James, 2005), hyperlipidemia, and fatty liver (Lau *et al.*, 2007). Fat deposition, which was once a plus for efficient energy storage, has now become a funnel of health risks. Available literature reports that the main factor causing the development of obesity is a decreased physical activity and an increased energy intake (Adams and Murphy, 2000; Westerterp-Plantenga *et al.*, 2005; Kushner 2007). In all cases, the consequence is the storage of surplus energy as excessive quantities of body fat (Keith, 2007).

Interestingly, awareness about the importance of nutrition in the maintenance of health and the prevention of disease has been enhanced (Clifford, 2000), making the science of nutrition a significant part of preventive medicine. Indeed, dietary regulation is known to be an important component of the treatment of ailments, especially those associated with overweight and obesity (Bhargava and Guthrie, 2002; Kopelman and Caterson, 2005; NICE 2006). Also, the therapeutic application of natural plant products in this regard have been recognized (Calixto, 2000). To this effect, it has becomes necessary to suggest that herbs and spices can be of utmost advantage to humans particularly in the management of obesity/overweight, which have assumed a global status. In fact, a report produced by Wanless (2007) for the King's Fund warned that unless further action was taken, obesity had the capacity to financially cripple National Health Service.

In line with the above therefore, this study focuses on *Yaji*, a complex Nigerian meat sauce used in serving the meat delicacy called 'Suya'. This complex combination of spices and additives (salt, monosodium glutamate (MSG), groundnut powder, ginger, cloves, red pepper, and black pepper) has become the subject of several scientific investigations (Nwaopara *et al.*, 2004; 2007a,b; 2008a,b; 2009; 2010a,b) which have suggested that an unregulated and excessive consumption of *Yaji* is harmful. The present study however, is designed to determine the effect of *Yaji* on body weight in adult Wister rats.

Materials and Methods

Materials of study

Clove, ginger, red pepper, black pepper, table salt, MSG (white magi or Ajinomoto) and groundnut, were purchased dried from Aduwawa market, Benin City; Nigeria. The spices and feed (growers mash from Bendel Feeds and Flour Mills, Ewu, Edo State) were crushed separately using an electric blender. Measurement of spices was carried out using Electric Balance (by Denver Company USA 200398. 1REV.CXP-3000) in the diagnostic Laboratory of the Department of Medical Laboratory Science, Ambrose Alli University, Ekpoma.

Experimental rats

Adult rats of an average weight of 188g were procured from the animal farm house of the Department of Physiology, College of Medicine, Ambrose Alli University, Ekpoma, and moved to the site of the experiment at No. 5B Palm-well Street, Ujemen, Ekpoma, were they were allowed to acclimatize for three weeks. The animals were separated into six groups (A – F) in 6 big cages (n = 24). Group A rats served as the control while group B – F served as the test groups. During the period of acclimatization, the rats were fed growers mash daily and water given *ad libitum*.

Substance administration and preparation

After acclimatization, each group received as follows: Group A (control) received 300g of feed (growers mash) only; B received 237g of feed plus 9g of each of the constituents of *Yaji*; C received 291g of feed plus 9g of clove; D received 291g of feed plus 9g of salt (iodize table salt); E received 291g of feed plus 9g MSG; F received 291g of feed plus 9g of ginger; G received 291g of feed plus 9g of red pepper; H received 291g of feed plus 9g of black pepper and I received 291g of feed plus 9g of groundnut daily. For the purpose of this study, feeding pellets were produced. This was done by sprinkling water onto a mixture of *Yaji* constituents and appropriate amount of grower's mash until a semi-solid paste was formed. The resultant paste was then split into bits and allowed to dry under the sun. The total feeding period was eight weeks but on each day, it lasted between 9:00am – 10:00am.

Data collection

At the end of every week and before the commencement of the next feeding week, 3 rats were selected at random for weighing and the average is recorded accordingly. The weighed rats were then taken to a separate non-observatory cage. At the end of the experiment, the average weights of the test group were then compared with that of the control.

Statistical analysis

Data were analyzed using the SPSS version 17 software package for ANOVA and $P<0.05$ was considered as the level of significance.

Results

After acclimatization, there was an increase in the weights of the experimental animals. However, after the experiment, diverse weight changes were observed in the groups. Comparing the changes with that of the control (262.57±34.84), we observed that there was a statistically non-significant ($p > 0.05$) weight gain in groups D, E and I with group E (277.88±73.80) posting the highest weight gains. On the contrary, a non-significant ($p > 0.05$) weight loss was observed in groups B, C, F, G and H (see figure 1). The observed weight changes were obvious in the 3rd week and were sustained till the end of the 8th week. Groups E, D, and I posted weight changes that remained higher than that of group A with group E and I posting sharp weight increases in the 3rd and 6th weeks respectively. The weights posted for groups B, C, F, G and H however, remained lower than that of the control. See Table 1 and Figure 1 and 2 showing the mean ± S.D of the weight of animals during the different periods of weight measurement.

On the whole, the spice treated groups posted weight losses, while the additive-treated groups, posted weight gains. The highest weight loss was recorded for group G, followed by those of group C and then B. See figure 1 below showing the weekly weight distribution and figure 2 showing comparative weight gains or losses before acclimatization; after acclimatization but before the experiment and after the experiment in all the groups.

Table 1: Average weight of rats at different stages of the experiment.

Group	Weight at difference stages (in gram)		
	Before acclimatization	**After acclimatization**	**After experiment**
A (Control)	188.13 ±10.63	203.13±8.92*	262.75 ±34.84**
B (*Yaji)*	188.13 ±8.54	200.94 ±7.12*	231.88 ±42.91**
C (Clove)	187.50 ±7.75	200.00 ±6.32*	231.75 ±20.85**
D (salt)	188.75 ±9.22	207.19 ±7.30*	266.75 ±41.41**
E (MSG)	187.50 ±9.31	205.31 ±8.26*	277.88 ±73.80**
F(Ginger)	187.50 ±9.31	200.0 ±6.06*	246.75 ±28.21**
G (R. pepper)	186.88 ±8.92	202.81 ±7.30*	230.63 ±16.28**
H (B. pepper)	185.63 ±4.03	204.06 ±4.91*	256.63 ±33.48**
I (G. nut)	185.63 ±9.11	204.38 ±6.29*	270.00 ±42.84**

A = control, B = *Yaji* (mixture of constituent), C = clove, D = salt, E = MSG, F = ginger, G = red pepper, H = black pepper, I = groundnut cake powder, * = significantly different when compared to the pre-acclimatization weight; ** = significantly different when compared to the pre-and post-acclimatization weight.

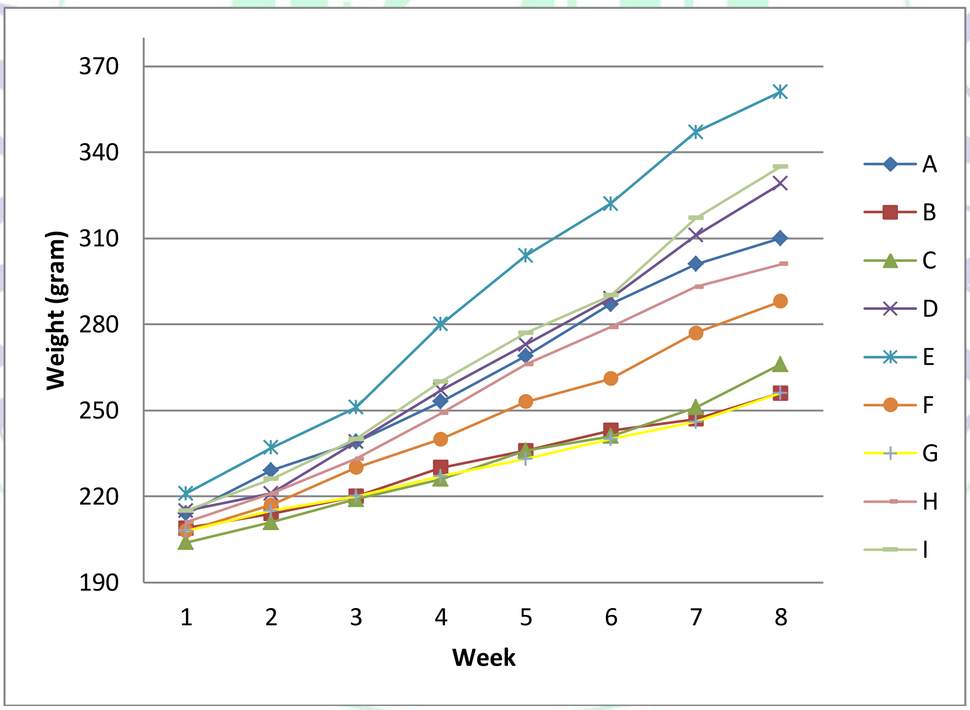

Figure 1: Line graph showing weekly weight changes of rats fed with *Yaji*, *Yaji*-spices and *Yaji*-additives.

Keys: A = control, B = *yaji* (mixture of constituent), C = clove, D = salt, E = MSG, F = ginger, G = red pepper, H = black pepper, I = groundnut cake powder.

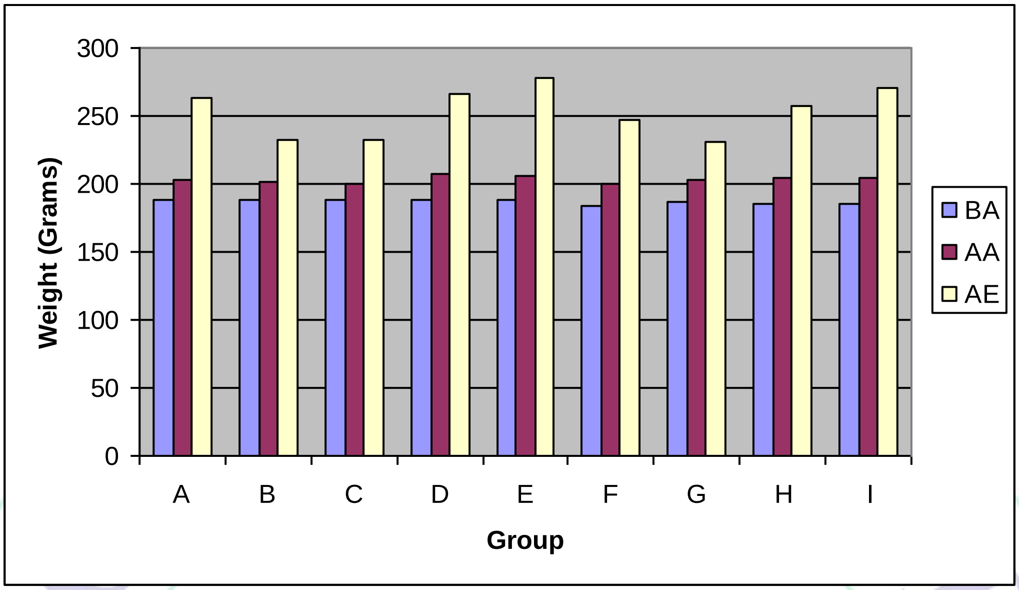

Figure 2: Cumulative weight gain of rats fed with *Yaji*, *Yaji*-spices and *Yaji*-additives for 8 weeks.
Keys: A = control, B = *Yaji* (mixture of constituent), C = clove, D = salt, E = MSG, F = ginger, G = red pepper, H = black pepper, I = groundnut cake powder, BA = before acclimatization, AA = after acclimatization, AE = after experiment.

Discussion

The spices in *Yaji*-ginger, cloves, red pepper and black pepper, contain gingerol (Witchtl, 2004; Westerterp-Plantenga *et al.*, 2006), eugenol (Pathak *et al.*, 2004; Lee and Takayuki, 2001), capsaicin (Lejeune *et al.*, 2003; Mori *et al.*, 2006; Westerterp-Plantenga *et al.*, 2006), and piperine (McGee, 2004; Westerterp-Plantenga *et al.*,2006) as active principles respectively, while the additives - ajinomoto, salt and groundnut cake powder, contain monosodium glutamate (Omojola, 2008), sodium chloride (Carson *et al.*, 1998; Tesco, 2010; The International Codex Alimentarius Standard for Food Grade Salt, 2006) and oil (Fageria *et al.*, 1997) as active principles respectively. This signifies that *Yaji* is indeed a complex of active principles and as such, the observed changes cannot be unconnected with the potential influences of such active principles.

However, irrespective of the possible influence of the active principles in *Yaji*, one should not lose sight of the other possibilities, which might have also contributed to the observed variations in weight (gain or loss). Specifically, the comparative lower weight in the *Yaji* and Spice-treated groups as compared to the relatively higher values for the additive-treated groups and control might be due to the repulsive effect of the hot and burning properties of the spices, which possibly led to reduced feeding (Oyewole *et al.*, 2007).

On the other hand, the observed weight gain in the additive treated groups particularly those treated with MSG, might be attributable to the established appetite enhancing potentials of MSG (Bellisle, 2008), which might have increased the feeding rates of the animals in that group. Whereas, some have found a negative relationship or no link between MSG consumption and body weight (Essed *et al.*, 2007; Kondoh and Torii, 2008; Shi *et al.*, 2010), others have suggested a link between MSG, energy overconsumption and weight gain (Hermanussen *et al.*, 2005; He *et al.*, 2008).

Our findings suggest that clove, ginger, red pepper and black pepper can induce weight loss, though not statistically significant; probably due to the study duration and dosage. Nevertheless, a comparative analysis on the potency to induce weight loss amongst the spices indicated that red pepper was more potent (230.63±16.28g); followed by clove (231.75±20.85g), ginger (246.75±28.21) and black pepper (256.63±33.48g) in that order, when compared with that of the control (262.75±34.84g). The observed changes in weight were duration dependent judging by the determined weekly mean values. In this regard, our findings were consistent with the research reports that 1) ginger can cause a decrease in body weight (Michael *et al.*, 2009); 2) weight gained in clove treated rats is significantly lower ($p<0.05$) than the control (Agbaje *et al.*, 2009); and 3) oral and gastrointestinal exposure to capsaicin (a constituent of red pepper) increases satiety and reduces energy and fat intake (Westerterp-Plantenga *et al.*, 2005). Our result is however, inconsistent with the reports by Hassan *et al.* (2010), that there was a significant increase in the body weight of black pepper treated rats for 5 weeks as well as that by Mbongue *et al.* (2005), that there was a significant increase in the body weight of black pepper treated rats after 55 days. With reference to later report, one would observe that the obvious determining factor at this point might be the variation in the study duration, a reason by which a fair comparison cannot be made nor sustained.

Fortunately, spices have a number of established properties that make them effective agents in the prevention and management of obesity. As Keith (2007) reported, spices are appetite suppressants; increase metabolic rate by stimulating the nervous system to release hormones like adrenalin; and reduce fat absorption. The result of this study is in line with these assertions as it relates to the potentials of the spices under study. In fact, it has been reported that piperine (a constituent of black pepper) can stimulate metabolism and binds to the so-called Transient Receptor Potential Vanilloid (TRPV1) receptors in the brain and other parts of the nervous system; and as TRPV1, works as the body's thermometer which, once activated, turns up the heat by boosting heat production by the body (Food Navigator, 2006). On the other hand, capsaicin has been reported to have effect on carbohydrates breakdown and may also be used to regulate blood sugar levels (Lejeune *et al.*, 2003). In this regard, further research was required to see if capsaicin would be useful to treat obesity and this study presents promising result. Interestingly, substance P in capsaicin has been shown to reverse diabetes in mice (Motluk and Geddes, 2005; Tsui *et al.*, 2007). Available reports have shown that capsaicin has the capacity to reduce adiposity in rats, which can be partly explained by its enhancing effects on energy and lipid metabolism via catecholamine secretion from the adrenal medulla through sympathetic activation of the central nervous system (Lejeune *et al.*, 2003).In addition, an increase in diet-induced thermogenesis with a decrease in RQ immediately after a meal containing capsaicin have been reported in humans (Yoshioka *et al.*, 1999; 2001), implying a shift in substrate oxidation from carbohydrate to fat oxidation.

On the contrary, the ingestion of salt, MSG and groundnut induced weight gains with MSG (277.88±73.80g) being the most potent. Our findings on salt is consistent with the study of Fonseca-Alaniz *et al.* (2007), who reported a non-significant difference ($p > 0.05$) in the body weights of the rats fed with normal, low, and high sodium diets at weaning (3 weeks) and during the 9-week follow-up period. The study by Hui *et al.* (2008), also reported that diets with different salt content fed to mature cats over a 6 month period produced no effect on food intake and body weight. High sodium diet have however, been shown to enhance water intake and urine output (Hui *et al.,* 2008). As such, the weight gain of about 4g caused by salt ingestion compared with the control in this study may be temporary as salt causes the body to retain water. Chronic dietary sodium restriction, an important non-pharmacological approach for the prevention and treatment of hypertension (Whelton *et al.,* 1998; Sacks *et al.,* 2001), has been linked with an increased white adipose tissue mass in rats (Prada *et al.*, 2000; Okamoto *et al.,* 2004; Prada *et al.,* 2005). If this increase in adiposity observed in rodents also applies to human beings, it could mitigate the beneficial value of this therapeutic approach in reducing blood pressure in hypertensive subjects. Moreover, if this increased adiposity is associated with high leptin plasma concentration, the potential injury can be even higher (Fonseca-Alaniz *et al.*, 2007).

Furthermore, the observed influence of MSG on weight gain is in line with the reports of Hermanussen *et al.* (2005), He *et al.* (2008) and Tsang (2008) that MSG improves palatability of meals and influences appetite positively (Bellisle, 2008; Carter *et al.*, 2011), hence the resultant increase in body weight. Although MSG improves taste stimulation and enhances appetite, available reports indicate that it is damaging to different organs (Moses and Sefcikova, 2004; Singh and Pushpa, 2005; Farombi, 2006; Eweka, 2007; Vinodini *et al.*, 2010). Moreover, the safety of MSG has generated much controversy. Research findings have shown that this flavor enhancer, found in many popular foods, causes weight gain and obesity in lab animals by damaging the appetite regulation center in the area of the brain known as the hypothalamus, causing leptin resistance

(Barbara, 2009). Previous studies on MSG and obesity have been conducted on human and weight gain was significantly greater amongst those that consume MSG than in those who do not, even when they were given similar portions of food (Tsang, 2008; Parker 2008). A possible explanation for this is the fact that MSG alters the regulatory mechanisms that affects fat metabolism (Tsang, 2008).

Another line of thought considers the influence of the groundnut in *Yaji*. Though earlier reports on nuts suggest that despite the high-energy content, the consumption of nuts does not induce weight gain (Hu *et al.*, 1998; Ellsworth *et al.*, 2001) even when total energy intake is substantially greater (Morgan and Clayshulte, 2000; Morgan *et al.*, 2002). For example, adding 48g of walnuts to the diet for 6 weeks did not induce weight gain although energy intake increased by 1661 kJ/day (Almario *et al.*, 2001). However, the result of our study on groundnut shows that it induced weight gain, and this is consistent with the reports by Alper and Mattes (2002) that the incorporation of whole peanuts to the habitual diet of healthy adults for 8 weeks resulted in a 1kg increase in body weight as well as that of Akuamoah-Boateng *et al.* (2007), who reported that there was a slight but significant increase in the body weight of participants consuming nuts oil within an 8-week intervention period. Again, the comparative factor appears to be duration since the nut intervention periods for the trials under reference were relatively short, and there were no indication of the impact of nut intake in the long-term. In fact, the report by Lovejoy *et al.* (2002) that ingestion of nuts can induce weight loss definitely adds to this controversy.

Interestingly, our findings on *Yaji* consumption as shown by the results from group B, suggest that *Yaji* can induce weight loss. This effect therefore, is probably due to the combined influence of the active ingredients in *Yaji* with potentials for body weight reduction. This was shown by the results on clove, ginger, red pepper and black pepper. It also indicates that *Yaji* has the capacity to induce weight gain as represented by the results on salt, MSG and groundnut. However, the capacities of salt, MSG and groundnut to induce weight gain is likely counteracted by the opposing influence of clove, ginger, red pepper and black pepper to induce weight loss. This indicates that *Yaji* consumption might not induce weight gain but help reduce body weight particularly if overweight has become the issue.

Therefore, the potentials in *Yaji* can be harnessed for weight management especially in cases of obesity, which has become a community health challenge requiring urgent attention. It is indeed our opinion that selected spices be added to soups and foods, which in our thinking may help check weight gain considering the fact that carbohydrate diets are predominant in our society. Also, relevant agencies involved in ensuring healthy nutrition in communities as well as food safety, should consider funding further research on this complex combination of active principles whose potentials are yet to be fully understood.

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