World Applied Sciences Journal 6 (7): 971-975, 2009
ISSN 1818-4952

Cholesterol Content, Physical and Sensory Properties of Pork from Pigs Fed Varying Levels of Dietary Garlic (*Allium sativum*)

A.B. Omojola, S.S. Fagbuaro and A.A. Ayeni

Meat Science Laboratory, Department of Animal Science, University of Ibadan, Ibadan, Nigeria
Department of Animal production, University of Ado-Ekiti, Ado-Ekiti, Nigeria

Abstract: Effects of dietary garlic consumption on cholesterol level, physical and sensory properties of pork were investigated. A total of forty eight (48) Large White cross bred weaner pigs aged six weeks were randomly assigned to four dietary groups in a completely randomized design. The garlic bulbs were separated into cloves, sun dried to 91.25± 1.26% DM, milled and incorporated into the ration to replace a fraction of cassava flour. Each treatment consisted of varying levels of garlic as 0.00, 0.50, 1.00 and 1.50% representing treatments G00, G05, G10, G15 respectively. The pigs were fed the experimental feed for 120 days, at the end of which 3 pigs per replicate were sacrified for meat total cholesterol and sensory evaluation. The cooking loss was highest ($P<0.05$) in the control diet with a value of 23.64% as against values of 20.75, 19.17 and 19.38% for G05, G10,and G152, respectively. The result showed a progressive reduction in total cholesterol level from 135.35 mg/100g in the control diet to 44.44 mg/100g in the diet with 1.50% garlic supplementation. The back fat thickness decrease with increasing levels of garlic in the diet. Panelists preferred pork from pigs on treatments G00 and G05 in terms of flavour, colour, tenderness and overall acceptability while the juiciness likeness increased as garlic supplementation increased. The result showed that dietary garlic supplementation reduced cholesterol level in pork while juiciness rating improved.

Key words: Garlic · Cholesterol · Pork · Physical properties · Sensory characteristics

INTRODUCTION

Due to increasing incidence of cardio vascular diseases, the teeming population of the world tends to be cautious of the amount of animal fat they consume. This has in turn led to a lower demand for high fat food including pork. The decreased acceptability of pork has adversely affected its market and general pig production. This is particularly obvious in the developing countries where the bulk of the final product of pig production is pork. Consumers are skeptical of pork as it is widely believed that its cholesterol level is high.

Cholesterol is an important biological molecule that has roles in membrane structure as well as being a precursor for the synthesis of the steroid hormone and bile acids. Both dietary cholesterol and that synthesized *de novo* are transported through the circulation in lipoprotein particles [1]. The synthesis and utilization of cholesterol must be tightly regulated in order to prevent its over accumulation and abnormal deposition within the body.

Over the last century, the amount and proportion of animal fat in human diets have increased in many societies. These increases have been associated with the occurrence of cardiovascular disease [2,3]. In western societies, coronary heart disease and arteriosclerosis are strongly related to the dietary intake of cholesterol and saturated fatty acid and are among the important causes of human mortality [4]. It is widely acknowledged that there is an urgent need to return to a balanced fatty acid diet by decreasing intake of cholesterol especially the type that have been implicated (low density lipoprotein) and saturated fats [5].

Extracts of garlic are known to reduce serum cholesterol levels in humans, inhibit cholesterol biosynthesis, suppress LDL (low density lipoprotein) oxidation, lower plasma fibrinogen and increase fibrinolytic activities [6,7] and thus possess anti-arteriosclerotic properties [8].

Dietary therapy is the first step in the treatment of hyper-lipidemia [9-11]. Garlic saponin had been implicated to inhibit key enzymes in the cholesterol and

Corresponding Author: S.S. Fagbuaro, Department of Animal Production, University of Ado-Ekiti, Ado-Ekiti, Nigeria

lipid biosynthetic pathways [12]. It is therefore the aim of this study to investigate the effect of dietary garlic supplementation on meat cholesterol level and also to evaluate sensory characteristics of meat from garlic fed pigs.

MATERIALS AND METHODS

A total of forty eight Large White cross bred weaner pigs of both sexes with an average weight of 10±0.55 kg were randomly allocated to four dietary treatment groups, in a completely randomized design. The four dietary treatments were G00, G05, G10 and G15. G00 is the control diet while treatments G05, G10 and G15 contained 0.5, 1.0 and 1.5% garlic respectively. Each dietary treatment was replicated thrice with four pigs per replicate. The feeding trial lasted 120 days. The pigs were housed individually in a standard pig house with facilities for wallowing provided.

At the end of the experiment, three pigs with an average weight of 51.24±1.23kg were selected from each replicate group and sacrificed to evaluate meat quality attributes, muscle total cholesterol and organoleptic characteristics.

Diet: Ingredients composition of the experimental diet is presented in Table 1. The garlic was separated into cloves, sundried to 91.25±126% dry matter (DM), milled to finess (0.5-1.0 mm) using a locally fabricated hammer mill and incorporated at varying levels into the ration as shown in Table 1. The milled garlic was incorporated into the ration to replace a fraction of cassava flour. The pigs were fed *ad libitum* while fresh cool water was available through-out the experimental period.

Feed Conversion Ratio: This was obtained as the ratio of weight gain to feed consumed.

Back Fat Thickness: This was measured with a graduated probe. The measurement was taken immediately post mortem between the 12th and the 13th rib when the carcass was still warm

Meat Quality: Cooking loss: Samples of known weights (100-120g) were taken from the thigh muscle of each carcass (n=18/treatment) and cooked in a moist-heat to an internal temperature of 72°C as measured using Fluke type K temperature probe attached to fluke 52 meters. The broths were manually separated and each cooked sample was cooled to room temperature (27°C), blotted dry and weighed.

$$\text{Cooking loss} = W_1\text{-}W_2/W_1\times100$$

Where:
W_1 = Weight of meat before cooking.
W_2 = Weight of meat after cooking.

Shear Force Determination: The evaluation of tenderness was performed using the modified Warner Braztler shear force procedure [13] by using the Instron Universal Testing Machine. The meat samples were cooked to an internal temperature of 72°C. Three cores of 1.0cm in diameter were removed from each cooked meat sample after the boiled meat has been allowed to cool to room temperature (27°C) The cores were removed using an electric coring machine. Each core was sheared at three locations parallel to the orientation of muscle fibre.

Table 1: Ingredient composition

	Treatments			
Ingredients(%)	G00	G05	G10	G15
Maize	9.00	9.00	9.00	9.00
Cassava flour	31.72	31.25	30.75	30.25
Palm kernel cake	40.00	40.00	40.00	40.00
Groundnut cake	7.00	7.00	7.00	7.00
Garlic	0.00	0.50	1.00	1.50
Blood meal	3.00	3.00	3.00	3.00
Dicalcium phosphate	8.50	8.50	8.50	8.50
Mineral/vitamin premix	0.25	0.25	0.25	0.25
Salt	0.15	0.15	0.15	0.15
Lysine	0.35	0.35	0.35	0.35
Analysed nutrient content (%)				
Dry matter	93.25	95.05	94.35	93.10
Crude protein	17.15	17.65	17.35	17.45
Crude fibre	18.00	18.72	18.65	18.53
Ether extract	11.00	12.00	11.50	9.50
Ash	8.50	8.00	7.50	8.00

Muscle Cholesterol: Total cholesterol was extracted from lyophilized meat (dry matter), after saponification with saturated methanolic KOH, according to the procedure of Naeem *et al.* [14], except that 3 extractions with cyclohexane were used [15]. Cholesterol was separated and quantified by normal phase HPLC (Column Zorbax Rx-Sil, 4.6mm i.d. x 250mm, 5μm particle size, Chrompack, Bridgewater, N.J.) with an HPLC system (HP 1000 series, Hewlett-Packard, Palo Alto, CA) equipped with an auto sampler and diode array detector adjusted at 206nm, a solvent (3% iso propanol in *n*-hexane) flow rate of 1mL/min. and injection volume of 30 μL. Total cholesterol content of each meat sample was calculated in duplicate based on the external standard technique from a standard curve area vs. concentration.

Sensory Evaluation: Samples for sensory evaluation were taken from the thigh muscle, cooked in plain water to an internal temperature of 72°C. The panelist consisted of 30 (15 male and 15 female) individuals who are consumers of pork and had participated in similar sensory evaluation. Equal bite size (7.5g) from each treatment was blind coded and order of presentation randomized. The samples were evaluated independent of each other on a nine-point hedonic scale for flavour, juiciness, colour, tenderness and overall acceptability.

Proximate Composition: Feed analyses for dry matter, crude protein, crude fibre, fat and ash were performed according to the method of the Association of Official Analytical Chemist [16].

Statistical Analysis: Data obtained were subjected to analysis of variance and where statistical significance was observed, the means were compared using Duncan's Multiple Range (DMR) test. The SAS software [17] was used for all statistical analyses.

RESULTS AND DISCUSSION

As shown in Table 2, the total cholesterol content decreased with increasing level of garlic supplementation. The control diet gave an average value of 135.35mg/100g total cholesterol as against the values of 133.30, 66.66 and 44.40 mg/100g obtained from pigs on G05, G10 and G15 dietary treatments respectively.

The ability of garlic to lower serum cholesterol has been demonstrated in experimental animals. It has been reported that steam distilled garlic oil [18, 19], the ether extract fraction of garlic [20, 21] and its enzymatic transformation products, allicin [22] might be responsible for the cholesterol lowering effect of garlic in animals. Since the reduction in meat cholesterol in this study became more prominent as the level of garlic supplementation increased, garlic could therefore be implicated. The decrease in cholesterol was probably due to decrease hepatic synthesis [23].

It should be noted that cholesterol can be obtained directly from the diet, or it can be synthesized in cells from 2-carbon acetate groups of acetyl-coenzyme A. Because the synthetic pathway is under feed back control from dietary cholesterol, the percentage of cholesterol arising from *de novo* biosynthesis or from the diet depends upon the amount of cholesterol that is ingested. Even, when cholesterol intake is very low, *de novo* biosynthesis will enable the production of the cholesterol required to supply the large variety of biological processes in which this molecule is involved. Therefore, under these conditions only direct alteration of cholesterol biosynthetic pathway would enable a more radical alteration of the final cholesterol levels of pork. Garlic saponin has been implicated to inhibit key enzymes in cholesterol and lipid biosynthetic pathways [12]. The result of this study is in agreement with the findings of Konjufca *et al.* [12], that garlic supplements have a dramatic effect on cholesterol biosynthetic pathway.

Tenderness is regarded as the most important sensory attribute affecting meat acceptability [24]. It has also been identified as the most critical eating quality characteristic which determines whether consumers are repeat buyers. As stated by Quali [25] and Smulders *et al.* [26], meat tenderization is a multi-factorial process dependent on a number of factors such as species, age, sex, muscle type, ante mortem stress and slaughter conditions The effect of garlic supplementation on meat tenderness in this study was not pronounced ($P>0.05$). The Warner Braztler shear force ranged from 5.20 kg/cm^3 in G05 treatment to 5.56 kg/cm^3 in G15 group.

Cooking loss was highest ($P<0.05$) in the control group than in treatments with garlic supplementation while similar values ($P>0.05$) were obtained in garlic treated groups. The reason for this could probably be due to the ability of garlic to prevent biosynthesis of lipid and reduce fat lay down [12] which could have affected the water holding capacity of the meat and invariably the cooking loss. The reduction in fat lay down as observed in progressive reduction in back fat thickness (Table 2) could be as a result of poor utilization of feed (poor feed conversion) as the level of garlic in the diet increased.

Table 2: Feed conversion ratio, muscle cholesterol and quality characteristics of meat from pigs fed graded levels of garlic

	Treatments			
	G00	G05	G10	G15
Feed conversion ratio	5.41±0.53[c]	6.03±0.78b[bc]	6.72±0.86[b]	8.50±0.72[a]
Muscle cholesterol(mg/100g)	135.35±4.80	133.30±5.12	66.66±3.10	44.40±2.11
Tenderness (kg/cm^3)	5.45±0.14	5.20±0.21	5.30±0.18	5.56±0.14
Cooking loss (%)	23.64±0.17[a]	20.75±0.16[b]	19.17±0.09[b]	19.38±0.12[b]
Back fat thickness (cm)	2.00±0.46[a]	1.94±0.64[a]	1.76±0.26[b]	1.54±0.28[c]

[abc] Means within each row followed by different superscripts are significantly different (P<0.05)

Table 3: Organoleptic characteristics of meat from pigs fed ration supplemented with garlic

	Treatments			
Parameter	G00	G05	G10	G15
Flavour	7.00±0.71[a]	6.78±0.52[ab]	6.06±0.44[b]	5.56±0.18[c]
Juiciness	5.84±1.12[b]	5.78±0.94[b]	6.50±0.34[a]	6.28±0.82[a]
Colour	7.23±0.15[a]	6.78±0.10[a]	6.39±0.17[b]	6.40±0.31[b]
Tenderness	6.67±0.20[a]	6.78±0.14[a]	6.00±0.18[b]	5.50±0.11[c]
Overall acceptability	7.39±0.40[a]	6.73±0.4[ab]	6.45±0.28[b]	6.51±0.16[b]

[abc] Means within each row with different superscripts are significantly different (P<0.5)

Sensory Evaluation: The flavour likeness decreased (P<0.05) as the level of garlic supplementation increased however, there was no significant difference (P>0.05) between the control and those on 5% garlic. The trend observed might probably be due to off flavour that emanates as a result of allicin which is an odourous compound found in garlic However, the score of 5.56 obtained for G15 fell between intermediate and like slightly.

Colour, tenderness and the overall acceptability likeness followed a similar trend with flavour. Juiciness is made up of two effects which are, the impression of moisture released during chewing and also the salivation produced by flavour factors [27] However, juiciness likeness increased with increase level of garlic in the diet, this might be due to the reduction in percent cooking loss as garlic supplementation increased.. The overall acceptability of meat from garlic supplemented ration ranged between like slightly to like moderately while the control fell within the range of like moderately to like very much.

CONCLUSION

The result of this study showed that pork with reduced cholesterol content can be produced by dietary garlic supplementation without compromising the organoleptic characteristics below the threshold of intermediate acceptance. However, the flavour likeness decreased (P<0.05) as the level of garlic supplementation increased .

REFERENCES

1. Dietschy, J.M., L.A. Woolett and D.K. Spady, 1993. The interaction of dietary cholesterol and specific fatty acids in the regulation of LDL receptor activity and plasma LDL-cholesterol concentrations. Ann. N.Y. Acad. Sci., 676 : 11-26.
2. Lichtenstein, A.H., 1999. Dietary fat. A history. Nutr. Rev., 57: 11-14.
3. Katan, M.B., 2000. Nutritional interventions. The evidence. Proc. Nutr. Soc., 59: 417-418.
4. Sacks, F.M., 2002. The role of high-density lipoprotein (HDL) cholesterol in the prevention and treatment of coronary heart disease. Am. J. Cardiol., 15: 139-145.
5. Evans, M., A. Roberts and A. Rees, 2002. The future direction of cholesterol-lowering therapy. Curr. Opin. Lipidol, 13: 663-669.
6. Bordia, A., H.K. Joshi, Y.K. Sanadhya and N. Bhu, 1977. Effect of essential oil of garlic on serum fibrinolytic activity in patients with coronary heart disease. Arteriosclerosis, 28: 155-159.

7. Harenberg, J., C. Giese and R. Zimmermann, 1988. Affect of dried garlic on blood coagulation, fibrinolysis, platelet aggregation and serum cholesterol level in patients with hyperlipoproteinemia. Arteriosclerosis, 74: 247-249.
8. Phelps, S. and W.S. Harris, 1993. Garlic supplementation and lipoprotein oxidation susceptibility. Lpids, 28 : 475-477 .
9. Howard, G., I.E. Wagenknecht, G.I. Burke, A. Diez-Roux, G.W. Evans, P. McGovern, F.J. Nieto and G.S. Tell, 1998. Cigarette smoking and progression of arteriosclerosis: the arteriosclerosis risk in communities. (ARIC study). J. Am. Med. Assoc., 279: 119-124.
10. Steyn, K., M. Steyn, A.S. Swanepoel, P.C. Jordan, P.I. Jooste, J.M. Fourie and J.E. Rossouw, 1997. Twelve year result of the coronary risk factor study (CORIS). Int. J. Epidemiol., 26: 964-971.
11. Villeneuve, P.J., H.I. Morrison, C.L. Craig and D.E. Schaubel, 1998. Physical activity, physical fitness and risk of dying. Epidemiology, 9: 626-631.
12. Konjufca, V.H., G.M. Pesti and R.I. Bakalli, 1997. Modulation of cholesterol levels in broiler meat by dietary garlic and corpper. Poult. Sci., 76: 1264-1271.
13. Bouton, P.E. and P.V. Harris, 1978. Factors affecting tensile and Warner Braztler shear values of raw and cooked meat. J. Textures Studies, 9: 395-413.
14. Naeem, E., N. Ahmad, T. Sharrah and M. Behzahani, 1995. Rapid and simple method for determination of cholesterol in processed food. J. AOAC Int., 78: 1522-1525.
15. Ponte, P.I.P., I. Mendes, M. Quaresma, M.N.M. Aguiar, J.P.C. Lemos, L.M.A. Ferreira, M.A.C. Soares, C.M. Alfaia, J.A.M. Prates and C.M.G.A. Fontes, 2004. Cholesterol levels and sensory characteristics of meat from broilers consuming moderate to high levels of alfalfa. Poult. Sci., 83: 810-814.
16. AOAC., 1990. The Official Method of Analysis. Association of Official Analytical Chemists 15th Edn., Washington DC.
17. SAS., 2000. SAS Users' Guide; Statistics Version. 8th Edn. SAS Institute Inc. Cary NC.
18. Abo-Doma, M.H., M.M. Said, N.E. Shakat, R.F. Riad, and A.R. Nassar, 1991. Effect of onion and garlic oils as well as some of their sulphur constituents on lipid metabolism in albino rats. J. Drug Res., 20: 1-11.
19. Kamanna, V.S. and N. Chandrasekhara, 1984. Hypocholesterolemic activity of different fractions of garlic. Indian J. Med. Res., 79: 580-583.
20. Bordia, A., S.K. Arora, L.K. Kothani, K.C. Jain, B.S. Rathore, A.S. Rathore, M.K. Dube and N. Bhu, 1975. The protective action of essential oils of onion and garlic in cholesterol-fed rabbits. Arteriosclerosis, 22 : 103-109.
21. Jan, R.C. and D.B. Konar, 1978. Effect of garlic oil in experimental cholesterol arteriosclerosis. Arteriosclerosis, 29: 125-129.
22. Augusti, K.T. and P.T. Mathew, 1974. Lipid lowering effect of allicin (diallyl disulphide-oxide) on long-term feeding on normal rats. Experienta, 30: 468-470.
23. Qureshi, A.A., Z.Z. Din, N. Abuirmeileh, W.C. Burger, Y. Ahmad and C.E. Elson. 1983. Suppression of avian hepatic lipid metabolism by solvent extracts of garlic: Impact on serum lipids. J. Nutr. 113:1746-1755.
24. Warkup, C.C., S. Marie and G. Harrington, 1995. Expression of tissue proteinases and regulation of protein degradation as related to meat quality. A. Quali, D. Demeyer and F.J.M. Smulders (Eds.). Ecceainst Ultrechct. The Netherlands, pp: 225-231.
25. Quali, A., 1990. Post-mortem changes in muscle tissue. J. Muscle Foods, 1: 129-134.
26. Smulders, F.J.M., B.B. Marsh, D.R. Swartz, R.L. Russel and M.E.J. Hoenecke, 1990. Beef tenderness and sarcomere lenght. Meat Sci., 28 : 349-368.
27. Omojola, A.B., O.A. Isah, M.K. Adewumi, O.O. Ogunsola and S. Attah, 2003. Evaluation of the effects of various additives on the acceptability of Kilishi. Trop. J. Anim. Sci., 2: 97-101.