Mineral profile and dietary mineral supplements on the concentrations of some minerals in the brain regions of pigs.

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Abstract

The nervous system though largely electrical in action is "powered" by its content of minerals which exist in ionic forms in nature and play a major role in neural action, membrane permeability and excitation. 20 grower boars were randomly assigned to two dietary groups of 10 boars each. The first ration was a conventional grower feed without vitamin/mineral premix while the second diet was supplemented with Agricare® premix* and more common salt than the conventional diet. The animals were fed ad libitum and slaughtered at 60kg body weight. The brains were dissected out into six brain parts namely: cerebellum, amygdala, hippocampus, hypothalamus, cerebral cortex and medulla oblongata, and immediately analysed for electrolytes. Calcium in the cerebellum and hypothalamus of mineral-supplemented pigs was significantly higher ($P < 0.05$) than concentrations in the pigs on unsupplemented diets. Calcium concentrations in the other brain regions did not show significant differences. Sodium concentrations were relatively stable in all the brain parts irrespective of dietary mineral supplementation although higher concentrations were recorded in the brain parts of pigs on mineral supplemented diets. However, sodium concentrations were higher in the cerebellum and cerebral cortex of the mineral-supplemented pigs with values of 15.0 mg dl^{-1} and 14.8 mg dl^{-1} which are significantly ($P < 0.05$) higher than concentrations of 11.8 mg dl^{-1} and 11.3 mg dl^{-1} respectively recorded for the pigs on the unsupplemented diet. This study has established a direct link between dietary minerals and salt on the mineral content of the pig brain

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Key words: Mineral profile, supplements, concentrations, brain regions, pigs.

Introduction

The understanding of the physiological responses of animals to both the exteroceptive and interoceptive agents is of importance to the improvement of livestock productivity.

The brain is the most complex and most highly organised form of matter known. Sex, species

and breed effects have been identified in the anatomy of the brain, the size of the brain regions and in the distribution of neurotransmitters (Arnold and Schlinger 1993, Adejumo and Egbunike, 2002).

Different brain regions exhibit different physiological functions and activities (Adejumo

and Egbunike, 2002) and the chemical constituents of the brain play a critical role in the physiological balance and integration of the animal (Reis *et al*, 1977, Ologhobo *et al*, 1986).

The nervous system though largely electrical in action is "powered" by its content of minerals which exist in ionic forms in nature and play a major role in neural action, membrane permeability and excitation (Ganong, 1997). The relationship between nutrition, body development and brain metabolites have been well documented (Adlard and Dobbing, 1971). Inadequate nutrition is reflected in a lowering of blood calcium or phosphorus or both (Woodward, 1969, Maynard and Loosli, 1956).

In this study, base line profiles of mineral concentrations in the medulla oblongata, cerebellum, cerebral cortex, hypothalamus, amygdala and hippocampus of mature pig brain and the effects of supplemental vitamin/mineral premixes on the concentrations of these minerals were investigated.

Materials and Methods

Twenty grower boars with an average weight of 25.4kg±2.41 were balanced for weight and randomly assigned to two dietary groups of 10 boars each. The first ration was a conventional grower feed without vitamin/mineral premix while the second diet had Agricare® premix* and more supplemental salt than the conventional

Table 1. *Formulation and gross composition of experimental rations*

<i>Experimental diets</i>		
Ingredients	T1 (Control)	T2 Vit/min pre mix
Maize	56.50	53.00
Groundnut cake	28.00	28.00
Fish meal	3.00	3.00
Dried Brewers' Grains	5.00	5.00
Blood meal	2.50	2.50
Bone meal	2.00	2.00
Oyster shell	1.50	1.50
Salt	1.50	2.50
Vit/Min Pre-mix*	0.00	2.50
Total	100	100

*Vitamin mineral premix contained (g kg⁻¹) diet: Thiamine (0.02), riboflavin (0.34), cyanocobalamine (0.00035), niacin (0.10), amino/aminobenzoic acid (0.10), retinyl acetate (0.04), ergocalciferol (0.04), choline HCL (200), CaCO₃ (15.258), COCL₂ 6H₂O (1.078), CuSO₄ 5H₂O (0.019), FeSO₄ H₂O (1.0787), MgSO₄ (2.292), MnSO₄ 2H₂O (0.178), KIO (0.032), K₂ PO₄ (15.559)

Table 2. Proximate analysis of the experimental diets

Parameters	T1 (Control)	T2 Vit/min pre mix
Crude Protein	22.23	22.23
Crude Fibre	4.66	4.66
Ether Extract	1.97	1.97
Ash	3.91	5.44
Moisture	6.00	6.00
Nitrogen free extracts	59.7	59.7
Metabolisable Energy (Kcal/kg)	3103	3103

diet. (Table 1). The proximate analyses of the diets were carried out according to procedures established by AOAC (1990) and are summarised in Table 2.

The animals were fed *ad libitum* till they attained a weight of 60kg after which they were fasted for 18 hours but allowed free access to water and slaughtered by strangulation followed by rapid bleeding and decapitation. The individual brains were thereafter quickly removed, freed of adhering meninges and superficial blood vessels, dissected out and homogenized in ice cold (1%w/v) deionised water using a Potter-Elvehjem glass homogeniser into six brain parts namely: cerebellum, amygdala, hippocampus, hypothalamus, cerebral cortex and medulla oblongata, as described by Egbunike (1981) and immediately analysed for electrolytes.

Calcium was analysed using Sigma kits (Sigma, 2000) while sodium and potassium were determined by atomic absorption photometry according to procedures described by Varghese *et al* (1969).

All results were subjected to the one-way analysis of variance using SPSS® (2000) statistical package and means compared by the t-test.

Results

Data in table 3 present the baseline concentrations of minerals in grower pigs raised on conventional diets and mineral/vitamin supplements. Calcium in the cerebellum and hypothalamus of mineral-supplemented pigs was significantly higher ($P<0.05$) than concentrations in the pigs on unsupplemented diets. Values for the cerebellum calcium of the mineral-supplemented and in the unsupplemented dietary groups were 1.3 mg dl⁻¹ and 0.84 mg dl⁻¹ respectively. The concentrations in the hypothalamus were 0.65 mg dl⁻¹ and 0.40 mg dl⁻¹ respectively. Calcium concentrations in the other brain regions did not show significant differences. Sodium concentrations were relatively stable in all the brain parts irrespective of mineral supplementation although apparently higher concentrations were recorded in the brain parts of pigs on mineral-supplemented diets. However, sodium concentrations were higher in the cerebellum and cerebral cortex of the mineral-supplemented pigs with values of 15.0 mg dl⁻¹ and 14.8 mg dl⁻¹ respectively which are

Mineral profiles in pig brain regions

Table 3. Relative organ weights (g 100g⁻¹) of rats fed extruded and non-extruded soybean and cowpea based diets

Parameters	Calcium		Sodium		Potassium	
	Diet 1	Diet 2	Diet 1	Diet 2	Diet 1	Diet 2
Cerebellum	0.84±0.18 ^b	1.3±0.0 ^a	11.8±1.3 ^b	15.0±0.4 ^a	13.56± 1.9	15.6±0.9
Cerebral cortex	0.71± 0.24	1.2± 0.35	11.3± 0.1 ^b	14.3± 0.39 ^a	14.9± 1.4	18.1±1.7
Amygdala	0.43± 0.07	0.54±0.08	10.9±0. 6	12.2 ±0.8	14.2± 0.6	15.4±0.7
Medulla						
Oblongata	0.42 ±0.1	0.67± 0.06	8.1±0.32	8.8 ±0.3	10.3± 0.4	11.1±0.3
Hypothalamus	0.40±0.09 ^b	0.65± 0.06 ^a	8.8 ±1.4	11.3± 2.9	11.7± 1.7	14.4±3.6
Hippocampus	0.30±0.07	0.42±0.12	7.8±0.6	8.9± 0.7	11.3± 0.6	12.2±0.8

Values are means ± SEM (Standard error of the means)

^{a,b}: Means along the same mineral column and brain region row differently superscripted differ significantly (P<0.05)

significantly (P<0.05) higher than concentrations of 11.8 mg dl⁻¹ and 11.3 mg dl⁻¹ respectively recorded for the pigs on the unsupplemented diet. Potassium ion concentrations in the brain regions were unaffected by dietary mineral supplementation although values recorded in the brain regions of the mineral supplemented animals tended to be higher than the mineral content of the pigs on the unsupplemented diets.

Discussion

Exteroceptive and interoceptive stimuli may alter the distributions of ions across cell membranes with measurable responses from the animal. Embedded within the cell membrane are channels with gates or valves that regulate the passage of specific ions through the membranes and this is responsible for the selective permeability of the cell membrane to a few ions. In addition to this, the blood-brain barrier creates a state of equilibrium for the brain to maintain the brain in

the "correct" electrical posture. By and large, electrical conductivity in the animal is essentially an ionic affair and the present study shows that in spite of mineral supplementation, the brain is able to maintain a balance or equilibrium. This would explain the relative stability of these minerals in most of the brain parts examined. Calcium ions are necessary for the release of transmitters at neuronal synapses (Collier and Ilson, 1977) and the increase in the cerebellum and cerebral calcium of pigs on mineral-supplemented diets suggests an increased stimulation of neural cells in the animals fed mineral-supplemented diets. A positive correlation between potassium concentration and growth has long been established (Brooks *et al*, 1962). Curtis *et al* (1967) found a positive interaction between potassium content and protein concentration. However, this study did not establish a consistent increase in brain potassium with dietary mineral supplementation. The importance of sodium ions in the well being of the animal is reflected in the higher sodium concentrations observed in the cerebellum and

cerebral cortex of the mineral supplemented pigs. The mineral-supplemented diets contained in addition to the premix, a higher salt content and although this study dealt with homogenized brain matter without separating intracellular or extracellular sodium ions, this study has established a direct link between dietary minerals and salt on the mineral content of the pig brain.

References

- Adejumo, D.O. and Egbunike, G.N. (2002):** Regional variations in acetylcholin esterase activity and total protein in the brain and hypophyses of Large White boars managed under a hot humid environment. *ASSET Series A.2* (1): 49-53
- Adlard, B. P. F. and Dobbing, D. (1971).** Elevated acetylcholinesterase activity in adult rat brain after under nutrition in early life. *Brain Research*, 30: 198-199
- A.O.A.C. (1990):** Official Methods of analysis. 15th Edition. Association of Official Agricultural Chemists. Washington, D.C.
- Arnold, A. P. and Schlinger, B.A. (1993):** Sexual differentiation of Brain and Behaviour. The Zebra Finch is not just a flying rat. *Brain. Behav. Evol.* Vol. 42: 231-234
- Brooks, J. R., Pipes, G.W. and Ross, E.W. (1962).** Effect of temperature on the thyroxine secretion rate of rams. *J. Anim. Sci.* 21: 412-416
- Collier, B. and Ilson, D. (1977).** The effects of preganglionic nerve stimulation on the accumulation of certain analogues of choline by a sympathetic ganglia. *J. Physiol.* 264: 489-492
- Curtis, S.E., herdenreich, C.E. and Martin, T.G. (1967).** Relationship between body weight and chemical composition of pigs at birth. *J. Anim. Sci.* 26: 749-751
- Egbunike, G.N. (1981):** Regional distribution of Acetylcholinesterase activity in the brain and hypophyses of crossbred European boars reared in the humid tropics. *Acta. Anat.* 110: 248-252.
- Ganong, W.F. (1997).** Review of medical physiology. 18th edn. Appleton and Lange, Stamford, Connecticut.
- Maynard, L.A., and Loosli, J.K. (1956)** Animal Nutrition. McGraw-Hill Book Company. Inc. New York. 343-360
- Ologhobo, A. D. Tewe, O.O. and Adejumo, D.O. (1986):** Serum Protein and neural metabolite in broilers fed Soya bean rations. In: Proc. 11th Annual Conference of the Nigerian Society for Animal Production. Zaria, Nigeria : 95 - 101
- Reis, D.J., Ross, R.A. and Joh, T.K. (1977).** Changes in the activity and amount of enzymes synthesizing catecholamines and acetylcholine in the brain, adrenal medulla and sympathetic ganglia of aged rat and mouse. *Brain Research.* 6: 465-474

Sigma (2000). Biochemicals and reagents for life science research: Diagnostic kits and reagents. Sigma-Aldrich Co.1999 catalogue, Dorset, UK. 2538-2704

SPSS Window ®(2000) Statistical Packages for the Social Sciences. SPSS/ Inc. Chicago, IL 60606.

Varghese, F.T.N., Lipton, A. and Huxham, G.J. (1969). Improved method for estimation of major cations in biological extracts. *Lab. Practice*, 18, 419-420.

Woodward, D.L. (1969). The effects of chronic mg deficiency on the distribution of mg, ca, Na, and K in the brain, muscle, Csf and plasma. *Nutr. Absts. and Rev.* 39.:7305.

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