

Qualitative Assessment of Reaching Movement pattern using Reach-To-Grasp Task on Albino Wistar Rat Fed with Fufu

ABSTRACT

Fufu is a popular food in West Africa made from fresh or fermented cassava. As a product of cassava, when not properly processed may lead to some neurological impairment. This study investigated the physical and neurological effects of fufu in male wistar rats. Two groups of animals were used for this study. Group 1 (control group N=10) received the normal rat feed while group 2 (n=10) received the fufu produce. Both were administered for about 5 weeks after which a reach-to-grasp experiment was carried out using the reaching apparatus. Their physical appearances were observed and it was seen that the group fed with fufu experienced some hair loss and other physical changes. Qualitative assessment of their reaching movements showed that the group fed with fufu performed poorly in the reach-to-grasp experiment than the control group. In the observation of the movement pattern of both groups, it was clearly seen that the group fed with fufu had difficulties aiming and grasping as well as withdrawing of food pellets during the experiment and they also showed signs of weakness due to the fact that they were not able to lift their limbs properly in order to reach the pellets on the pedestal, therefore showing under reaching movements. Conclusion: the prolonged consumption of not properly processed fufu has both physical and neurological effects on the albino wistar rat.

Key words: Fufu, motor impairment, gasping, pronation, supination, cassava.

INTRODUCTION

Fufu is a staple food in Nigeria, West Africa. It is made from fermented cassava dough and can be eaten when dipped into an accompanying soup. Across Africa it has various names: fufu in Gabon, fufuo in Ghana, and in Nigeria it is called fufu, akpu, loi-loi and so on. Fufu is a product of cassava and therefore may cause the same neurological effect that can be caused by improperly processed cassava roots due to its cyanogenic glycoside content. In the various traditional preparations of cassava, there may be some residual cyanide content because of insufficient tissue disintegration during cassava processing and insufficient washing. It is the residual cyanide that is responsible for toxicity.

Table 1 - HCN content of fufu during processing

Food item	Detoxification stage	Remaining HCN	
		Mean (mg/kg)	(percentage)
Fufu	Fresh roots (sweet and bitter)	111.5	100.0
	Soaked roots (3 days)	19.4	17.4
	Dried roots (3 days)	15.7	14.1
	Uncooked fufu (flour and water)	2.5	2.2
	Cooked fufu	1.5	1.3

Source: Bourdoux et al. 1982; Oke, 1984.

Prolonged and continuous intake of cyanide from a cyanide dominated diet has been proposed to be a contributing factor in two forms of nutritional neuropathies, tropical ataxic neuropathy in Nigeria (Osuntokun, 1981) and epidemic spastic paraparesis (Cliff et al., 1984). These disorders are also found in some cassava growing areas of Tanzania and Zaire.

According to lykkesfeldt and moller (1994), cassava accumulates cyanogenic glycosides linamarin and lotaustralin in roots and leaves in ratios of about 93: 7, they release hydrogen cyanide upon cell disruption through the catabolic action of B-glucosidases (linamarases). Cyanide toxicity occurs as a result of its chemical binding to cytochrome c oxidase, blocking the mitochondrial electron transport chain with subsequent inhibition of tissue aerobic respiration. (Geller et al. 2006; Isom et al. 1982)

MATERIALS AND METHODS

Fresh locally processed cassava (fufu) was bought from the local markets in Port Harcourt, Rivers State, Nigeria. It was analyzed in the Department of Pharmacognosy, Faculty of Pharmacy, University of Port Harcourt, Rivers State Nigeria.

Two groups of five weight-matched animals each were used for the study. Group 1 was treated with the normal rat feeds while Group 2 animals received only the fufu products. After about two weeks of acclimatization the group 2 animals were administered the cassava products for about 5 weeks after which the animals were trained for 6 weeks to perform the reach to grasp experiments and the data were collected. A qualitative evaluation of reach-to-grasp movements was performed using a reaching rating scale modified from earlier descriptions (Miklyaeva and Whishaw 1996; Mckenna and Whishaw 1999). The following six movements, which comprise the entire behaviour, were rated:

1. Advance - the head is raised, the elbow is adducted to the body midline, and the forelimb moves through the aperture towards the food;
2. Digits open - the digits are opened and spread as the limb advances;
3. Pronation - the limb is pronated above the target and moves down onto the food with the digits spread to palpate the area of the pellet;
4. Grasp - the limb remains relatively still while the digits are closed. During the grasp, the paw may be supinated to adjust and grasp the piece of food;
5. Withdrawal - the paw withdraws from the shelf, firmly holding the piece of food;
6. Release - the food is adjusted so that it is grasped by both paws, so that one end can be inserted into the mouth for chewing (Whishaw and Coles 1996). Each movement was rated on a 0 - 2 point scale. A score of 2 was given, if the movement was normal (as compared with typical movements of a control rat). A score of 1 was given, if the movement was recognizable, but was abnormal, usually being assisted by another body part. A score of 0 was given, if the movement was absent and replaced by another body movement. (Ballerman et al. 2001). Rat movements and pattern were analyzed using tracker software (Video Analysis and Modeling tool, Douglas Brown 2020 version 5.1.2). Cyanide analysis was carried out on 5.60g of fufu sample at a titre value of 0.010ml. Where 1 ml of silver nitrate used is equal to 2CN (Cyanide)

$$\text{Mg/kg} = \frac{\text{Titre value} \times 2(\text{CN})}{\text{Weight of sample}} \times 1000$$

Table 2 – Analysis of Fufu sample

Food item	Titre	Mg/kg
fufu 5.60g	0.010ml	3.57

RESULTS

Physical changes in rats Fed with Cassava

The animals administered fufu showed signs of physical changes such as hair loss in the head and back region, swollenness of the limbs around the interphalangeal joints and distal phalanges, weakness of the body and also the death of some rats.



(A) Control



(B) Fufu

Fig. 1: Comparison of physical appearances in hair loss of control rat and rat fed fufu

**Qualitative assessment of reaching movement for baseline (control)
rat using reaching movement scale**

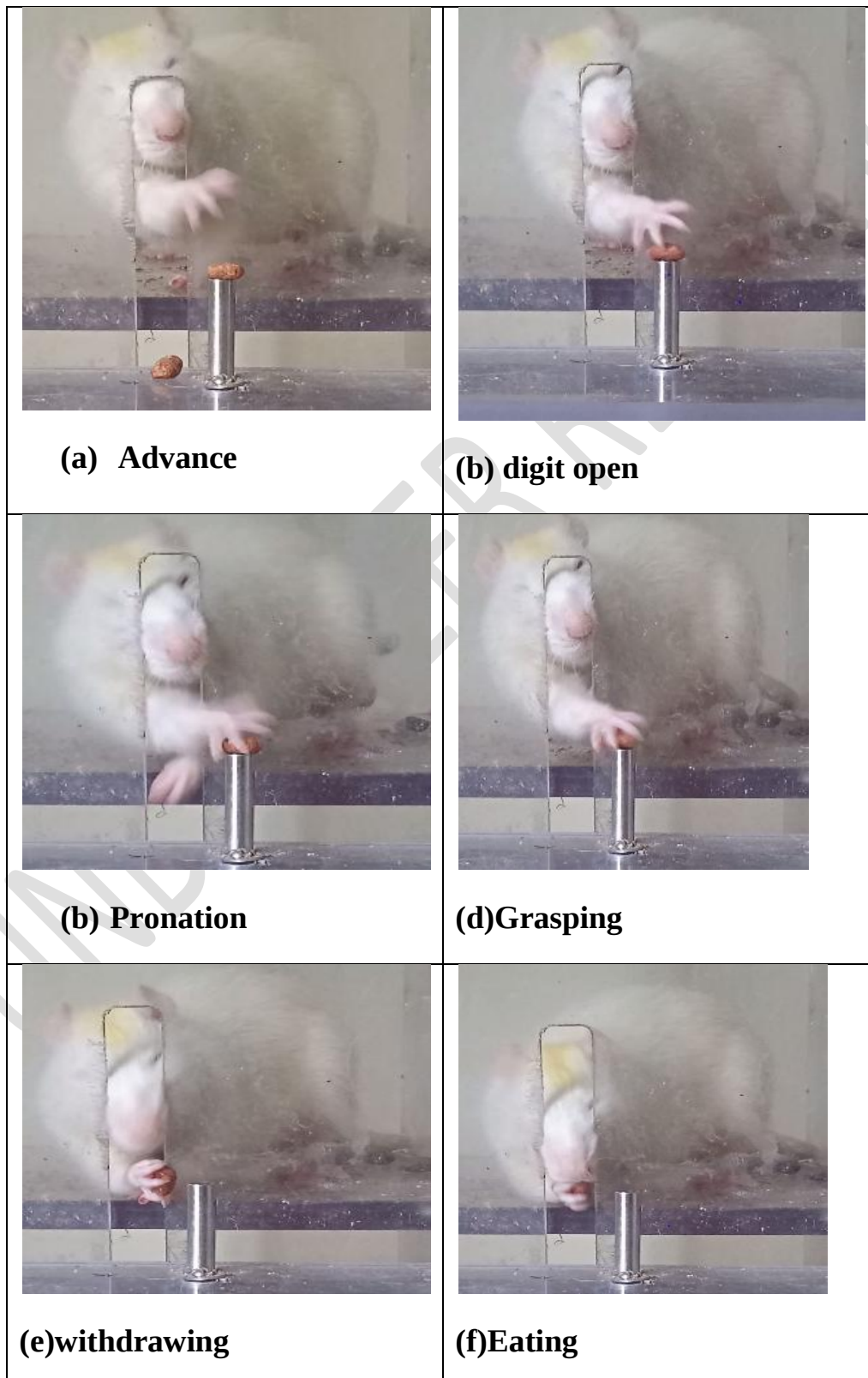
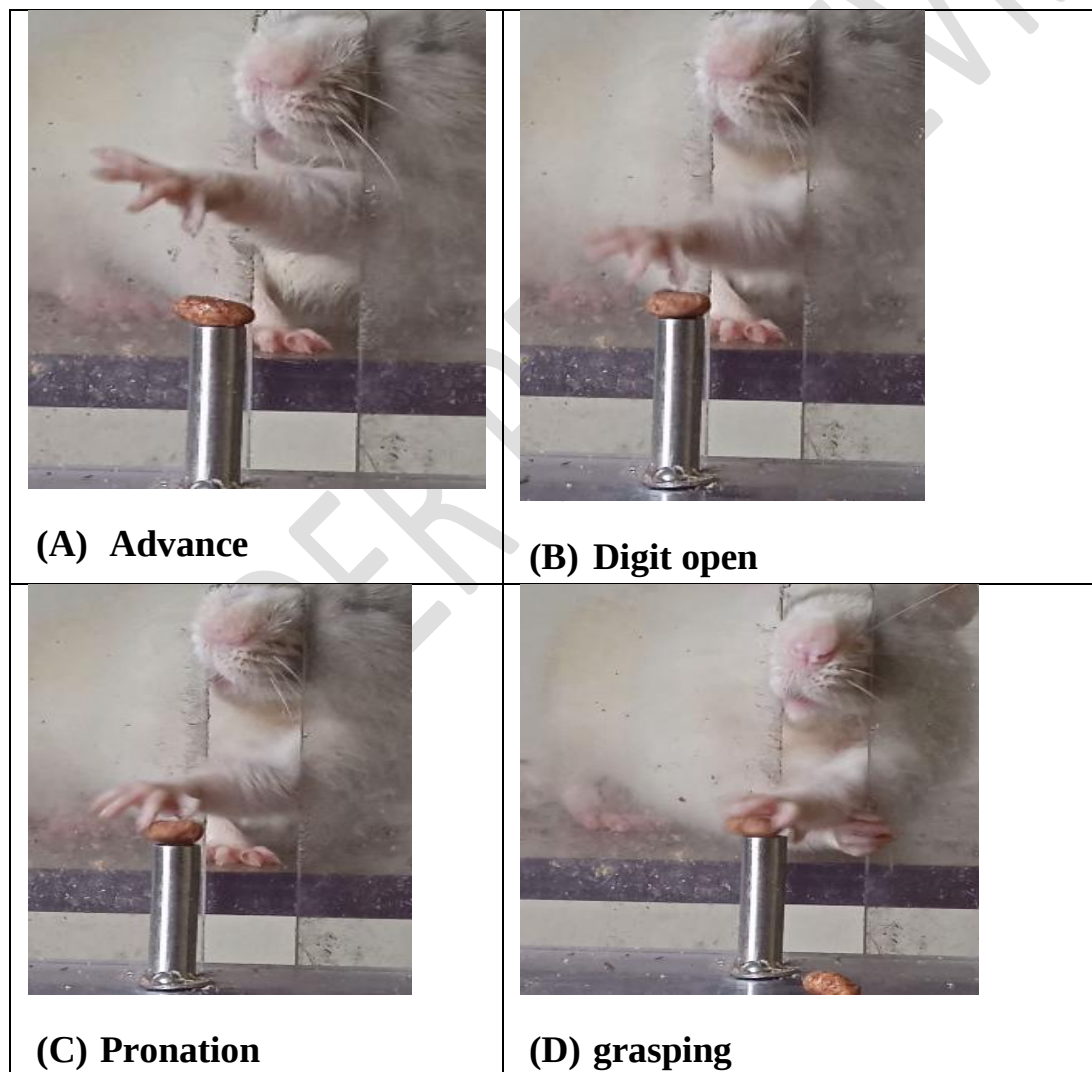


Fig. 2 Qualitative assessment of paw and digit movement made by control rat using reaching movement scale

The control rats (fig 2) showed no signs of impairments as it reached for the pellets with precision and accuracy. Its left limb was firm on the ground as it used only its right upper limb to reach for the pellets. During the weeks of the training the rats showed no signs of weakness and their aim and success in the experiment was at a consistent level above the 70% mark.

Qualitative assessment of reaching movement for rat fed with fufu using reaching movement scale



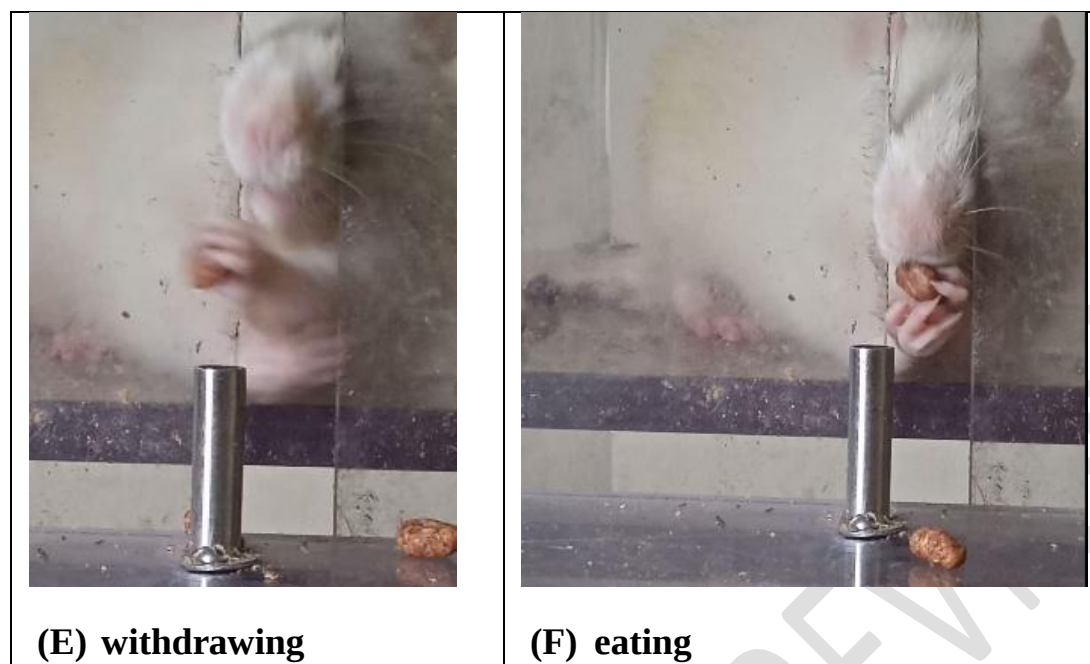


Fig. 3 Qualitative assessment of paw and digit movement made by rat administered fufu using reaching movement scale

Fig. 3 showed that the administration of fufu affected the performance of the rats as they were not able to effectively aim at the pellets therefore showing aiming impairment. It was observed that the animal used its left limb in reaching for the pellets while the right limb was also raised to support the left limb particularly during grasping. The rats performed poorly than the controls in the reach to grasp experiment due to some amount of weakness as a result of the fufu product that was administered.

Under-reaching Movements in Rat fed with with fufu

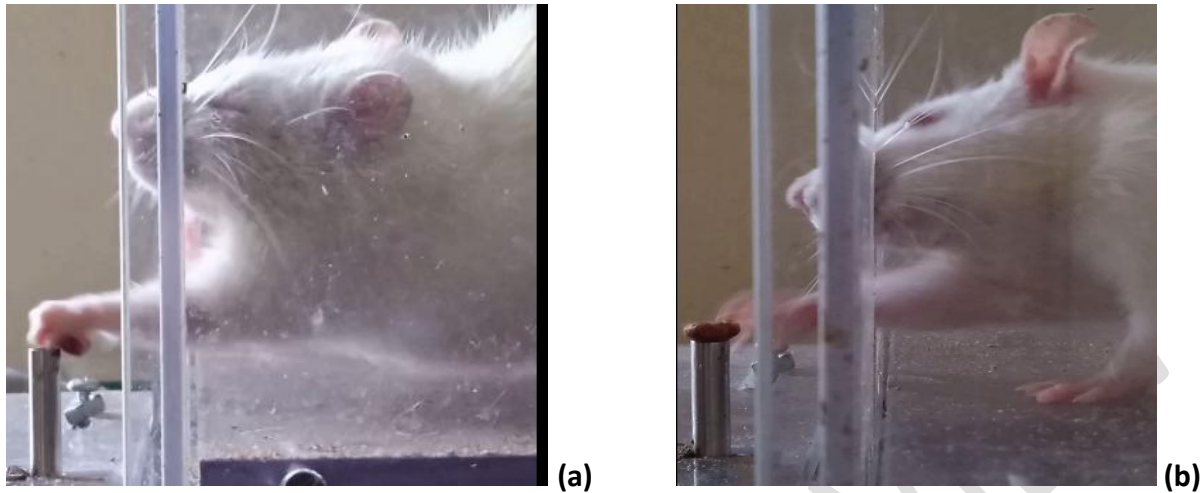


Fig. 4: under-reaching observed in impaired rat (a) Baseline Rat trained to reach with precision and accuracy (b) Under-reaching observed in rat fed with Fufu.

DISCUSSION

The physical appearance of the animals was compared across the groups (fig. 1). It was observed that the animals fed with Fufu were affected physically (fig. 1B), as it showed more signs of hair loss in the head and back region and also swollenness of the limbs was observed especially around the interphalangeal joints and distal phalanges. The rats showed an extreme amount of weakness with partial blindness observed in some rats in which their eyes were often closed. Muscle wasting and thinning was observed in the neck, abdomen and thighs and wounds take a very long time to heal. Under-reaching was also observed in the group administered Fufu (Fig 4B). They were not able to effectively reach the pedestal in order to grab the pellets. In Fig. 3, the paw of the rat became weak and the food pellets dropped occasionally. The advance movement was not directed at the pellet showing aiming impairments. The rats used the second paw to support the preferred paw during grasping of the single pellet to the mouth. This supporting behaviour was not seen in the control rats (fig 2). It was observed that during the reaching movement of the control rat, the second paw was on the floor, the rat only used one paw to reach and grasp the pellet to the mouth.

Our observation is in accordance with those of previous studies that stated how compensatory body movements provided the rotator movements to assist pronation and supination after a motor cortex injury in rat (Whishaw 2000; Kolb et al.2000; Biernaskie and Corbett 2011). In the work of Farr and Whishaw (2002), they compared control and stroke induced animals and observed that although the digits seemed to align with the body in both animals, the stroke animals achieved alignment in part by using body rotation. The control animals were able to advance the paw from the 'aiming' position directly through the slot towards the food, whereas the stroke

animals directed the paw through the slot diagonally. A similar result was observed in this present study. There were impairments in the limbs of the rats fed with the cassava products as the movement was altered even when the rats successfully obtained the food. The paw and elbow were not aligned to the aiming position along the midline of the body, but rather moved diagonally towards the food.

We confirm that rats fed with the fufu product had impairment in their success in retrieving food pellets using the paws, in which a success was counted only when the food was retrieved on a single reach. A video analysis of the reaching movements using tracker software indicated that the rats fed with cassava showed uncoordinated movement, with variable trajectories from trial-to-trial. The rats made several attempts before getting the pellet. This is an indication of aiming impairment.

CONCLUSION

Our study shows that the continuous consumption of not properly processed cassava product (fufu) causes both neurobehavioural and physical changes in albino wistar rats.

RECOMMENDATIONS

We recommend that the findings of this study be used as a baseline for other studies; and for advocacy to the Government to invest and improve the quality of cassava stems for planting, as this will help reduce the farmers to have better yield that are safe for consumption.

REFERENCES

- Ballerman, M., Metz, G.A.S., McKenna, J.E., Klassen, F. and Whishaw, I.Q. (2001) The pasta matrix reaching task: a simple test for measuring skilled reaching distance, direction and dexterity in rats. *J Neurosci Methods*. 106:39-45.
- Biernaskie, J. and Corbett, D. (2011) Enriched rehabilitative training promotes improved forelimb motor function and enhanced dendritic growth after focal ischemic injury. *J Neurosci*. 21: 5272-5280.
- Bourdoux, P., Seghers, P., Mafuta, M., Vanderpas, J., VanderpasRivera, M., Delange, F. & Ermans, M.A. (1983) Traditional cassava detoxification process and nutrition education in Zaire. In Delange, F. & Aklowalia, R. eds. *Cassava toxicity and thyroid: research and public health issues*, p. 134-137.
- Cliff, J., Martelli, A., Molin, A. & Rosling, H. (1984) Mantakassa: an epidemic of spastic paraparesis associated with chronic cyanide intoxication in a cassava staple area of Mozambique. *WHO Bull.*, (62): 477-484.
- Farr, T.F. and Whishaw, I.Q. (2002) Quantitative and qualitative impairments in in skilled reaching in mouse after a focal motor cortex stroke. *Stroke*. 33(7):1869-1875.

Geller RJ, Barthold C, Sakers JA, et al. (2006) Pediatric cyanide poisoning: causes, manifestations, management, and unmet needs. *Pediatrics*.118:2146–2158.

Isom GE, Burrows GE, Way JL. (1982)Effect of oxygen on the antagonism of cyanide intoxication--cytochrome oxidase, in vivo. *Toxicology and applied pharmacology*.65:250–256.

Kolb, B., Cioe, J. and Whishaw, I.Q. (2000) Is there an optimal age from recovery motor cortex lesion? Behavioural and anatomical consequences of unilateral cortex lesion in perinatal, infant, and adult rats. *Restorative Neurol Neurosci*. 17:61.

Lykkesfeldt, J. and Moller, B. L., (1994) Cyanogenic glycosides in cassava, *Manihot esculenta* Crantz. - *Acta chem. Scand*. 48. 178- 180

McKenna, J.E. and Whishaw, I.Q. (1999) Complete compensation in skilled reaching success with associated impairment in limb synergies, after dorsal column lesion in rat. *J Neurosci*. 19:1885-1894.

Miklyeva, E.I. and Whishaw, I.Q. (1996) Hemi Parkinson analogue rats display active support in good limbs versus passive support in bad limbs on a skilled reaching task of variable height. *Behav Neurosci*. 110(1):117-125.

Oke, O.L. (1984)Processing and detoxification of cassava. In *Symp. Int. Soc. Root Crops*. 6. Lima, 21-26 February 1983. p. 329-336. Lima. International Potato Center.

Osuntokun, B.O. (1981). Cassava diet, chronic cyanide intoxication and neuropathy in the Nigerian Africans. *World Rev. Nutr. Diet.*, (36): 141-173.

Tylleskar T., Howlett, W.P., Rwiza, H.T., Aquilonius, S.M., Stalberg, E., Linden, B., et al. (1993) Konzo: a distinct disease entity with selective upper motor neuron damage. *J Neurol Neurosurg Psychiatry*. 56:638-645.

Whishaw, I.Q. (2000) Loss of the innate cortical engram for action patterns used in skilled reaching and the development of behavioural compensation following motor cortex lesions in the rat. *Neuropharmacol*. 39:788-805.

Whishaw, I.Q. and Coles, B.L. (1996) Varieties of paw and digit movement during spontaneous food handling in rats: postures, bimanual coordination, preference and the effect of forelimb cortex lesions. *Behav Brain Res*. 77(1996):135-148.