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# VARIATIONS IN MATERNAL DIETARY FATTY ACID COMPOSITION AFFECTS THE NEURODEVELOPMENT OF RAT PUPS

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**Abstract**

Fatty acids are part of the structural matrix of cellular and subcellular membranes. Alterations in tissue fatty acid composition can affect nerve tissue function by altering membrane thickness or by changing properties of the lipid phase. In this study, the appearance of specific neurodevelopment responses was observed on rap pups whose dams were fed on varied dietary fatty acid composition. Three dietary treatments of corn oil, fish oil and reference meals were administered on these groups of pregnant dams. From postnatal day 5 to 30, littered pups were assessed daily for the appearance of neurodevelopmental reflexes based on the Smart- Dobbing method. The neurodevelopmental attributes of Righting reflex, Cliff avoidance, Negative geotaxis, Auditory startle, Vibrissa placing, Free-fall righting and Visual placing was observed in experimental pups between day 5 and 30. Tests were conducted between 1200 and 1400h. A 30 seconds time limit was employed in testing of the cliff-avoidance and negative-geotaxis appearance. The time appearance of auditory-startle and vibrissa-placing responses were significantly delayed ($P<0.05$) in pups of dietary fish oil – fed dams than those of corn oil fed dams. The delay in auditory-startle response may be due to negative myelination of the auditory brainstem pathway.

**Key Word:** Fatty Acid, Neurodevelopment, Rat Pups

## INTRODUCTION

Although maternal dietary fat have been known to have significant effects on neonatal and postnatal development, the exact nature as regards the development of body tissues have elicited so many research interests. Many researchers have factored considerable effects on the nervous tissue (Zuricr, 1993; Anibeze, 2012). This has led to so many research studies geared towards understanding the differences of fatty acid composition in humam milk, other mammals' milk and infant formula. Ning et al (2016) found the content of linoleic acid in bovine milk (2.48%) to be only one-seventh of human milk and formula milk (18.87%). The trends of alpha-linoleic acid in human milk increased significantly throughout the lactation while a decreasing trend was observed in both bovine and formula milks. They suggested a distinction between human milk and infant formulas in order to meet infants' personalized nutrition, especially the fatty acid composition in the first month of delivery.

Fatty acids are one of the constituents of phospholipids which make up the structural matrix of cellular and subcellular membranes (Monisha et al, 1998). Alterations in tissue fatty acid composition can affect tissue function by altering membrane thickness or by changing properties of the lipid phase (Zuricr, 1993; Barbara et al, 2007). Thus tissues such as the neurilemma surrounding myelin shearths with significant fatty acid content can be affected significantly by changes in fatty acid composition. Clandinin et al (1980) found that large quantities of long chain polyunsaturated fatty acids are deposited in the central nervous system during brain growth. This would suggest that fatty acid composition of developing neural tissues can be altered in animals by changes in dietary fatty acid composition. These alterations have been found to reflect on several measures of neurodevelopment such as reflex development (Zuricr, 1993; Wainwright, 1993), visual acuity (Neuringer, 1980) and exploratory activity (Enslen et al, 1991).

The role of dietary fatty acids in human infant development has been controversial. For instance, the enhanced neurodevelopment reported in beast-fed infants as against the


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formula-fed ones has been related to the higher levels of fatty acids in the human milk (Wainwright, 1993). However, the functional consequences of the difference remain unclear. Indications have often pointed to fatty acid compositions and lipid oxidation after a period which may impair the nutritive value of infant formulas. Paola et al (2015) found no difference in the fatty acid compositions at the beginning and after 30 days in some studied formulas. This study examines the effects of three levels of dietary fatty acid composition on the neurodevelopment of rat pups as measured by simple well coordinated neurodevelopmental reflex appearance of Smart and Dobbing (1971).

## MATERIALS AND METHODS

Pregnant rat dams were obtained from the Animal science Department of the University of Nigeria, Nsukka. Three different

**Table 1: Fatty Acid Composition of Diets fed to Rats throughout experimental duration Diet (g)**

| | Diet (g) | | |
|---|---|---|---|
| **Ingredients** | **Corn oil supplement** | **Fish oil supplement** | **Reference** |
| Rice brain | 20 | 20 | 20 |
| Maize | 22 | 22 | 22 |
| Bambranut | 20 | 20 | 20 |
| Vitamin/Mineral | 2 | 2 | 2 |
| Bread floor | 20 | 20 | 20 |
| Common salt | 1 | 1 | 1 |
| Corn oil | - | - | - |
| Fish oil | 5 | 5 | 5 |
| | **100** | **100** | **100** |

**Table 2: Smart and Dobbing (1971) Description of reflex tests used to assess the effect of diet on neurodevelopment in rat pups**

| Reflex | Eliciting Stimuli | Response |
|---|---|---|
| Righting reflex | Rat placed on back on flat surface | Turn unto ventral surface |
| Cliff avoidance | Rat put on edge of board with nose and fore feet just over edge. | Withdrawal of head and both fore feet from edge. |
| Negative geotaxis | Rat placed head downwards on a 200 slope. | Turns to face up the slop |
| Auditory startle | Snap of mousetrap closing | Sudden, brief extension of Hind limbs. |
| Vibrissa placing | At held by tail, virbissa Just touching vertical Surface. | Lifts head and extend fore legs in direction of bench |
| Free-fall righting | Rat dropped, back down-wards from 2ft, unto cotton | Turns in mid air to land on all four |
| Visual placing | Rat held from edge of bench by tail without vibrissa | Lifts head and legs in direction of bench. |

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**Table 3: Neurodevelopment reflex appearance in rat pups of dams fed fish oil, corn oil and reference diets during pregnancy**

| Reflex | Fish oil supplement | Corn oil supplement | Reference |
|---|---|---|---|
| Righting reflex | 4.1 +0.9 | 4.2 +1.1 | 4.1+0.8 |
| Cliff avoidance | 7.4+ 1.0 | 6.7+ 1.5 | 6.5 + 0.4 |
| Negative geotaxis | 7.9+ 2.6 | 9.9 +3.2 | 7.8 +1.2 |
| Auditory startle | 12.7 +0.0* | 11.6+ 0.8 | 10.9+1.2 |
| Vibrissa placing | 13.1+ 3.6 | 11.0 +1.9 | 1.4+ 1.2 |
| Fre-fall righting | 14.7+ 1.3 | 14.4+ 1.7 | 14.6+1.5 |
| Visual placing | 22.1 +1.1 | 21.9 +0.9 | 21.6+2.1 |

Values are means ± SD = 5 pups per dam, 3 dams per group. Values are significantly different (P<0.05).

diet groups were prepared with corn oil supplemented food, fish oil supplement food, and a reference diet to give diets of varying fatty acid composition (Table 1). On post-natal day 5 after all dams have littered, pups in each diet group were randomly distributed amongst dam. Five pups each were left for a dam in a cage. With three groups paper diet treatment, the experiment was conducted with a total of nine cages. Each cage contained diet and water chambers, which were changed every day. Weaned pups after day 20 commenced feeding on the corresponding material diet.

Using the Smart and Dobbing (1971) reflex assessments (Table 2), the time of appearance of neurodevelopmental reflexes was observed in experimental pups between day 5 and 30. Tests were conducted between 1200 and 1400h. A 30 seconds time limit was employed in testing of the cliff-avoidance and negative-geotaxis appearance.

## RESULTS

It was observed that length of gestation, dam weight gains, number of pups per litter and pup weights up to post-natal day 5 did not differ among diet groups. After day 5, weights of the corn oil-fed dams were significantly greater (P<0.05) than weight of pups of the fish oil fed dams.

Table 3 presents the findings from the Smart and Dobbing reflex assessments. All the items assessed showed variations in time of reactivity. But only the auditory – startle and vibrissa-placing responses were significantly delayed (P<0.05) among pups of fish oil group relative to corn oil group. The time of appearance of the remaining reflexes did to differ significantly among pups of different diet groups. There were no differences observed in the appearance of reflexes according to gender of pups.

## DISCUSSION

The control for differences in body weights and randomization of pups of dams fed the different diet groups before day 5 of commencement of neurodevelopmental assessments is indicative of the fact that any resulting changes would be attributed to dietary effects. Thus the significantly slower growth rate and delay in the time of appearance of auditory-startle reflex observed in pups of dams fed fish-oil supplemented diets could only be attributed to diet effects. Lec et al (1996) in their experiment observed that the auditory-startle reflex circuit includes afferent cochlear fibers and neurons of the cochlear nucleus which are structures that are essential in transmission and generation of auditory brainstem response. Thus the observations in the present investigation show that variations in fatty acid diets have significant effect in the auditory brainstem development of rat pups. These results support previous observation on rat pups (Smart and Dobbing, 1971; Enslen et al, 1991). However, the observance of significant delay in vibrissa-placing response of pups of dams fed fish oil supplemented diet cannot be explained.


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This investigation has relied on tests of visually evoked response to assess dietary fatty acids effects on the neurodevelopment of pups. The limitations of the techniques are well documented (Lec et al, 1996). However, it has been successfully used in the assessment of infants (Weinstein et al, 1991) and animal pups (Birch et al, 1992). More complex methods such as electrical potentials have corroborated results in most cases with carefully monitored visually evoked responses.

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