

Chapter 16

A Prototype Metabolic Cage for Rats and Mice for Biomedical Research in Nigeria

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Introduction

Animal experimentation is a regular feature of biomedical research and training. The common laboratory animals used include rats, mice, guinea pigs, rabbits, frogs, cats, dogs, monkeys, pigeons and hamsters (Badyal & Desai, 2014). These animals are typically used for research relating to drug discovery, the endocrine system, cosmetic testing (mutagenicity, phytotoxicity, genotoxicity, allergy, etc.) and toxicology. Ethics and animal use regulations require humane handling and reduction of pain of experimental animals (Flecknell, 2002).

For biomedical research requiring the collection of urine and faecal samples from laboratory animals, samples should not be contaminated with feed and water. Such research may involve analysis of metabolites and toxic products, or assessment of the state of vital organs by urinalysis. Urine and faecal analyses enable a researcher to know the health or physiological status of the animal (Kurien et al., 2004). There is therefore a need to find means of collecting uncontaminated urine and faecal samples, and metabolic cages provide such a means. These cages allow for separate collection of urine and faeces for analysis. Housing laboratory animals in metabolic cages enhances studies on the pharmacological, pharmacodynamic and toxicological effects of new substances, drugs and feed. Veterinary clinicians and biomedical researchers, therefore, often require metabolic cages for research on small and large laboratory animals.

Metabolic cages are commercially available and are produced using different materials, including plastic and polycarbonated stainless steel (Kurien et al., 2004). A general requirement or such a cage is that it must have a compartment with a wire mesh floor to allow urine and faeces to be collected in the funnel chamber below. The faeces roll down the side of the funnel into a collecting chamber or mesh. The feed chamber is usually located outside the cage and constructed in such a way as not to allow feed to get into the cage or resting chamber and thereby contaminate urine and faeces. The water bottle is calibrated and located outside the cage; it is usually provided with a spillage collecting funnel linked to a tube to prevent contamination of urine and faeces in the main chamber.

A major constraint in Nigeria is the fact that these laboratory cages are not readily available because of their cost. Most clinicians, researchers and institutions that require the cages import them, and a unit typically costs more than US\$500. A number of local

researchers have, therefore, devised different methods for the collection of urine and faecal samples. Some have used crude wire mesh housing placed on bowls, while others have used wooden boxes with wire mesh and net to collect samples. These methods, however, may impose a lot of stress on laboratory animals, thereby altering experimental results (Eriksson et al., 2004).

The aim of this project was to design and fabricate a safe, compact and affordable metabolic cage for small animal experimentation especially for rats and mice, that would meet the requirements of end-users including biomedical researchers.

Needs assessment

A needs assessment indicated that a metabolic cage with a unit cost of less than US\$100 would be acceptable to the end users, including nutritionists, pharmacologists, physiologists, biochemists and research students. The cage should be constructed to prevent trauma to the laboratory animal.

Design parameters

The design parameters for the cage as specified by the users are outlined below.

- It should be able to adequately separate urine and faecal samples and prevent contamination from water and feed.
- It should be made of materials that are resistant to corrosion, easy to clean and can be autoclaved.
- The component parts should be easy to detach and assemble for ease of cleaning and disinfection.
- Provision should be made for adequate ventilation in the cage.

Prototype

The component parts of the prototype metabolic cage that was developed are presented in Figures 1 to 6. Stainless steel was used in the construction of the cage stand, housing and floor. This is because it is readily available in Nigeria, relatively inexpensive and resistant to corrosion from urine and water soiling. Provision was made for the collection and separation of urine and faecal samples for analysis, as well as for water spillage and feed contamination control. Urine collection is done by a calibrated tube, which is placed beneath the cage and allows for the measurement of urine volume. Provision was also made for the measurement of feed consumption and quantity of water supplied or consumed. The quantity of feed supplied can be compared with what remains in order to obtain the daily consumption. The quantity of water consumed daily can be determined by subtracting the quantity of water left in the water bottle from the quantity supplied. Safety standards were followed for the housing compartment, these include the choice of

non-corrosive, non-toxic stainless steel, medium gauge wire mesh of 1–2mm diameter to prevent injury to the feet of the animals, and welding and folding of the joints and edges to prevent injury to the animals. The wire mesh will provide adequate ventilation. Feeding, watering, and spillage outlet facilities were provided to prevent cross-contamination. The components of the cage are detachable, and therefore easy to clean and replace when necessary.

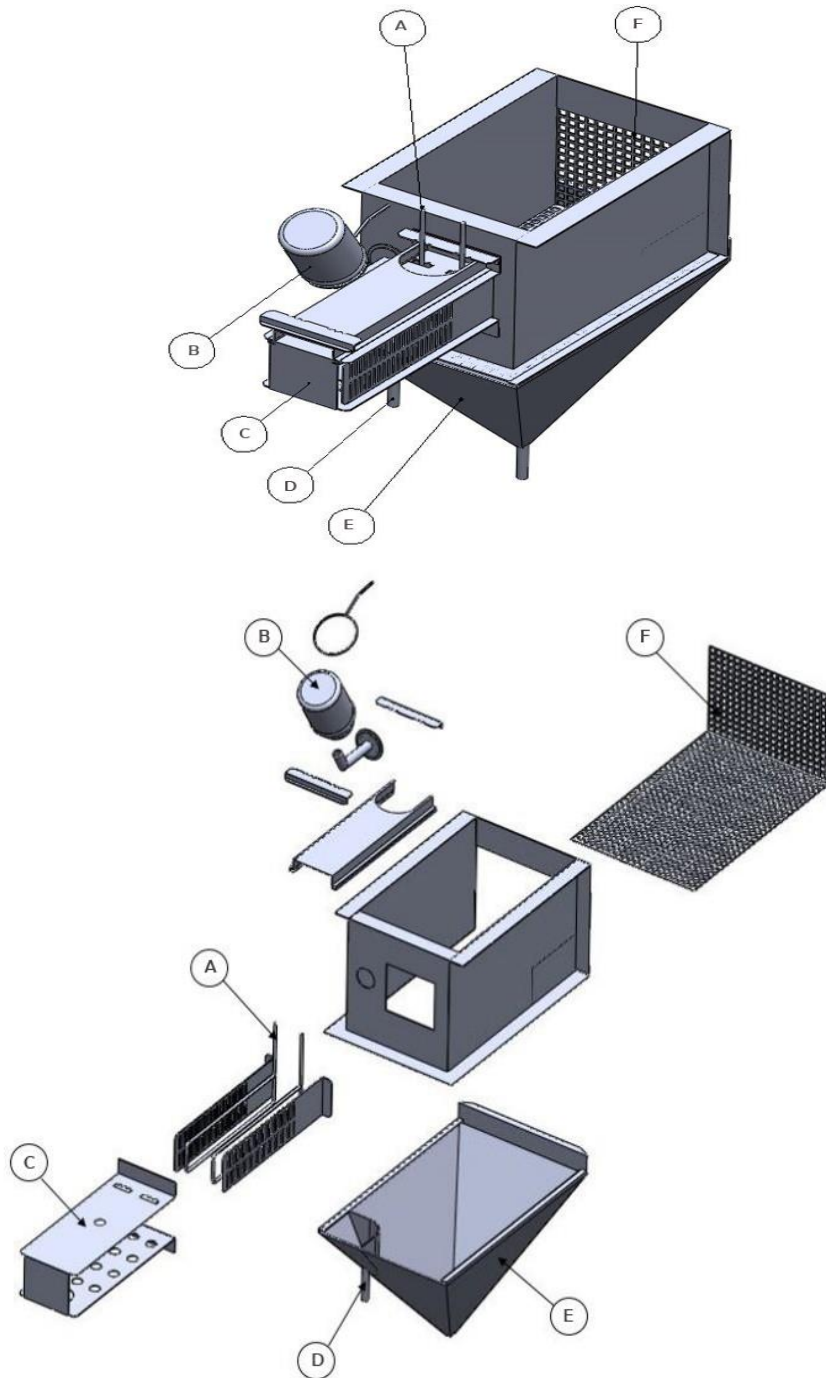


Figure 1: Views of the prototype metabolic cage. A: adjuster (for adjusting the resting compartment to suit the size of animal), B: water bottle, C: resting compartment, D: water drainage pipe, E: base hopper (funnel for collecting faeces), F: wire mesh.

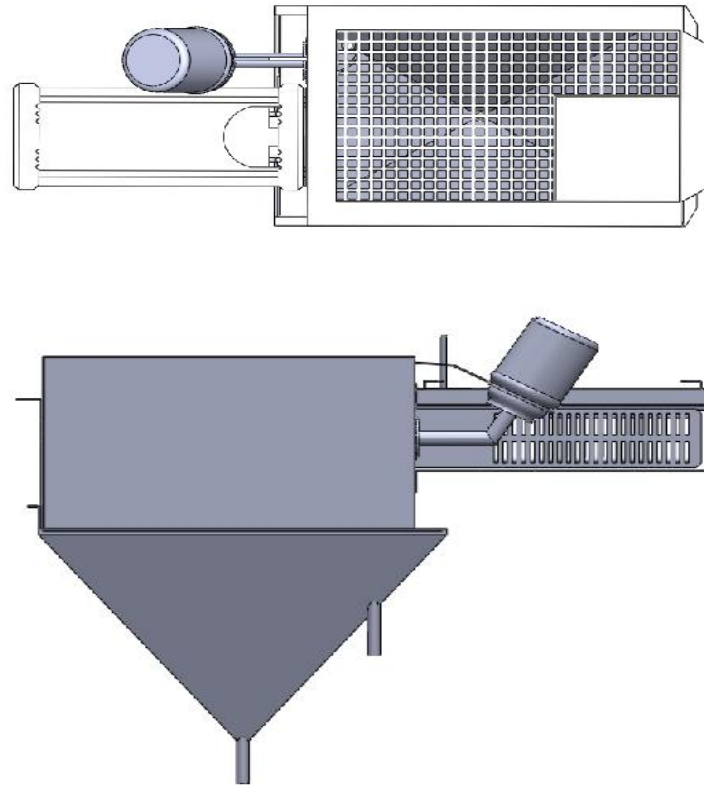


Figure 2: Top view (top) and side view (bottom) of prototype metabolic cage.

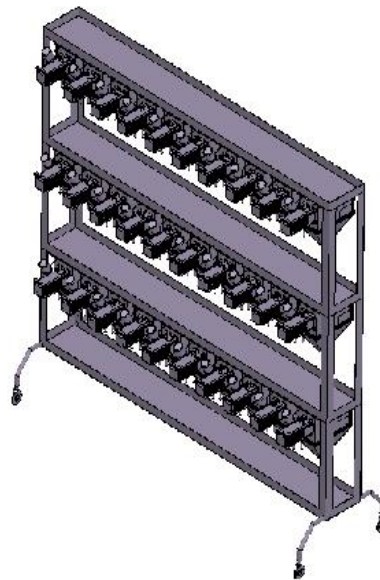


Figure 3: 30-unit metabolic cage stand with cages. Cages are connected to a rack attached to the bottom of a horizontal plate. The horizontal plates serve as cover for the cages and as base on which urine collecting jars are arranged in alignment with the urine collecting outlets of the cages above them. The stand has wheels for mobility.



Figure 4: Top, left: side view of the metabolic cage with open slits (blue arrow) on the resting compartment for ventilation; adjustable side plates (green arrow) to suit rodent size; and playing, feeding and drinking unit (black arrow), where feeding and drinking accessories are fixed. Top, right: upper part of cage, which is attached to cage stand; wire mesh (red arrow) on which the rodents stand; and resting compartment (blue arrow). Bottom: base of cage with resting compartment (black arrow); and wire mesh (blue arrow) on floor of cage.

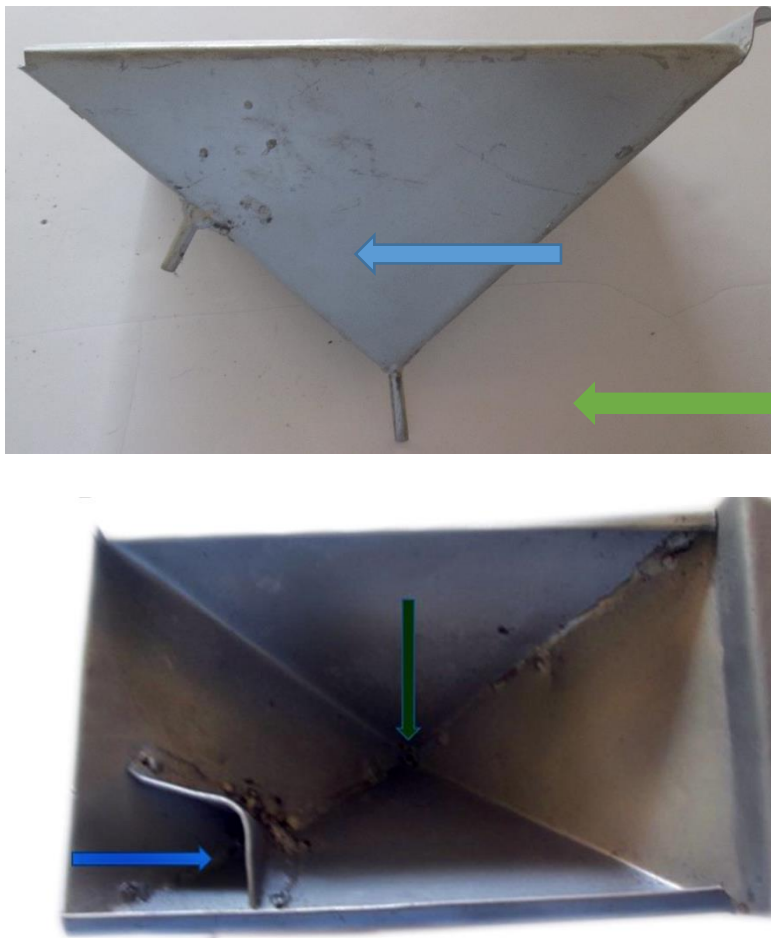


Figure 5: Top: side view of base hopper, spilled water outlet pipe (blue arrow) and urine outlet pipe (green arrow).

Bottom: Inside view of the base hopper with openings for spilled water outlet (blue arrow), and urine outlet (green arrow). The urine outlet prevents urine contamination by water drops from the drinking bottle while the animals drink from it.



Figure 6: Rodent drinking bottle with water spillage control nipple.

Cost Analysis

The total cost for the manufacturing of a unit of the prototype metabolic cage for rats and mice was US\$80, which met the requirement of the end users. The unit cost is expected to go down with increased production.

Conclusion

A prototype of a compact, detachable and affordable metabolic cage for small animal experimentation has been developed for biomedical research in Nigeria. The cage meets end-user requirements in terms of cost, functionality and safety. Larger-scale production of the cage is expected to bring down its unit cost and facilitate medical and biomedical research in Nigeria.

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