Chapter Three
Design of experiments

3.1 Principles of Experiment Design

The principles that researchers consider when designing experiments to eliminate/reduce the potential biasing effects of variables and/or increase the precision of the comparison of the treatments are explained. The difference between experimental and measurement units is also discussed.

3.1.1 Randomization

Randomization should be used to assign treatments to experimental units. For example, suppose that there are 40 oranges available for the study and labelled 1, 2, 3, ..., 40 and then mix them thoroughly. Pull out 20 slips of paper. These twenty slips of paper identify 20 oranges to be microwaved and the remaining slips identify the remaining twenty oranges that do not get microwaved. This approach is called a completely *randomized design*.

3.1.2 Blocking

Blocking refers to a statistical technique that attempts to eliminate potential confounding by grouping experimental units into blocks or groups with similar values on an extraneous variable and then randomly assigning treatments within each of the blocks, independently from block to block. The procedure may also result in a more precise comparison between the treatments on the response variable. In the block design there is grouping and then within each group randomization to treatments is carried out. This is called a *block design*.

3.1.3 Direct control

It refers to control an extraneous variable by using experimental units that all have the same value on the extraneous variable. In the meat heating example, an attempt was made to directly control the sizes of the pieces of meat across the meat types. The same burner was used to heat all 45 pieces of meat. The pieces of meat were placed at the same location in the pan, which is direct control of the effects of location on the response.

3.1.4 Replication

Replication of a treatment refers to a series (2 or more) of repetitions of the treatment to different independent experiment units. The experimental units could be individuals, groups of individuals, time slots, or runs of some process. The multiple repetitions are referred to as *replicates*.

Consider an observational study to compare the heights of adult males and females. If we only sampled one male and one female at random (no replication) we might just by chance obtain a taller female and then make the wrong conclusion that females are taller than males. Obviously this would be wrong. If we replicate the "*treatments*" (male and female), that is sampled independently many males and many females, the "*true*" pattern would emerge.

3.2 Power and Sample size

We return to design and consider the issues of choosing and assessing sample sizes. As we know, an experimental design is determined by the units, the treatments, and the assignment mechanism. Once we have chosen a pool of experimental units, decided which treatments to use, and settled on a completely randomized design, the major thing left to decide is the sample sizes for the various treatments. Choice of sample size is important because we want our experiment to be *as small as possible* to save time and money, but big enough to get the job done. What we need is a way to figure out *how large an experiment needs to be* to meet our goals; a bigger experiment would be wasteful, and a smaller experiment won't meet our needs.

3.3 Approaches to Sample Size Selection

There are two approaches to specifying our needs from an experiment, and both require that we know something about the system under test to do effective sample size planning. First, we can require that confidence intervals for means or contrasts should be no wider than a specified length. For example, we might require that a confidence interval for the difference in average weight loss under two diets should be no wider than 1 kg. The width of a confidence interval depends on the desired coverage, the error variance, and the sample size, so we must know the error variance at least roughly before we can compute the required sample size. If we have no idea about the size of the error variance, then we cannot say how wide our intervals will be, and we cannot plan an appropriate sample size.