IMPROVEMENT OF OPTICAL RED –BRIGHTNESS OF CHILLIE POWDER

By

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DECLARATION

I declare that this project is the original work of G.A.Chamanie Sirisena at the Faculty of Applied Sciences Under the supervision of Dr. K.K.D.S.Ranaweera and Mr.S.S.B. Navaratna

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AFFECTIONATELY DEDICATED TO MY PARENTS, BROTHERS, SISTERS, TEACHERS AND FRIENDS

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ABSTRACT

The colour of dry chillie (*Capsicum annuum*) powder is the principal criterion for assessing its quality and value. The first assessment on the quality of chillie powder is usually made on visual appearance. A major part of the consumer's willingness to accept the product is dependent upon its red bright colour.

A study was conducted to determine the practicable and economical method in enhancing the colour and factors responsible for the colour change of ground chillie during its storage.

The factors, which can effect on the initial colour and colour retention properties of dried chillie powder, were identified to measure behaviour of visual appearance of the product. Accordingly, five possible variables such as moisture content, seed pericarp ratio, exposure time to air, particle size and nature of packing material were taken for the present study. In accordance with the statistical design "2 factor factorial design", 32 samples with three replicates were analyzed in the current experiment. Results were collected from the trial conducted on colour by sensory means in every three-week period after forming a sensory panel.

The study was carried out to find out the effect of the above five factors on the enhancement the colour and colour retention during storage. It was revealed that $a_1b_1c_1d_1e_1$ was the best condition and preparation of the raw material and packing material to prolong the shelf life. Chillie containing 8% moisture level was capable of retaining colour. Was also revealed that chillie samples containing a large proportion of seeds were more susceptible to colur deterioration. The particle size of the chillie powder influenced the colour retention during storage. Packing material played an important role in the retention of colour during storage. In order to enhance the bright red colour of chillie powder, exposing chillie powder to air after grinding is more susceptible for enhance the bright red colour.

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CHAPTER 1
1. INTRODUCTION

The chillie plant (*Capsicum annum*) belongs to the family of Solanaceae, and genus *Capsicum.* The home of the capsicum is known as Tropical America. The introduction of *Capsicum* spices into many areas of the world follows their discovery by European explorers in the New World. The production of chillie as a marketable crop had achieved substantial levels throughout Asia from the India subcontinent, through South East, Asia and China to Japan (Senavitatna and Appadurai, 1996).

The consumption of chillie is highly popular among Asian countries, as well in Sri lanka. The dry powder of chillies has been used as a spice and also as a medicine. After drying, the chillie pods is used for making dry chillie powder. This is the most important form of *capsicum* in tropical countries.

Red pepper is used in many Maxican, Italian, and Indian dishes in order to achieve a pungent taste, like hot sauce, chillie con carne, soup, speghetti, pizza, chicken, fish, vegetable dishes, pickles, a few egg dishes, meats and curries. It is used frequently at household level.

At the commercial level, red pepper is used in chillie powder blends, pickling spices and in many meat seasonings where it replaces part of or adds to the black pepper bite, especially in the sweet and hot Italian sausage seasonings. It is also used in seasonings for bologna, frankfurters, smoked country sausage, Mexican sausage, mortadella, pepperoni, Cappicala, pizza leaf, pork sausage, pork patties, German bologna, chicken loaf, liver wurst and Braunschweiger liver wurst. And also used in condiments, pickles, soups, baked commodities, confection and nonalcoholic beverages. It is used medicinally as a counterirritant and as a carminative (Farrell, 1999).

In Sri lanka, the production of chillie powder is a broad spectrum and spread it from domestic scale to industrial scale while releasing a hedge volume into the competitive and dynamic market. A large proportion of production is being of taken by the domestic consumers, while perceiving to a point where quality and price to be compromised, as the product being prevailed a higher demand.

However, quality of production is the main parameter for the demand in the competitive market. Quality in dry chillie powder is based on a high degree of pungency, a good flavour and bright red colour.

The colour of dry chillie powder is the principal criterion for assessing its quality and value. The first impression to generate quality on the product is usually dependant on visual appearance and a major part of our willingness is to accept the product also depends upon its red color. The color of product may vary considerably, from place to place, and from season to season, depending upon numerous factors including modern technical knowledge.

The main contributors to red colour in chillie are carotenoids, a group of pigment occurring naturally in plants. The main carotinoid is a red pigment called capsanthin, usually found associating with another red pigment called capsorubin.

Colour deterioration during processing and the storage of ground chillie is a critical factor, confronted with manufacture in the dynamic market while viably prohibited the competitive edge for product. Hence low colour chillie, as a result, the production as well as the profit being sealed down while creating a less consumer appeal that results a high degree of market return.

The most important controllable factors affecting color retention of the dried products during storage are temperature, fat content of the seed, moisture content, particle size of the powder, air and the packaging material in the micro environment. The aim of this study is to determine the factors, which can influence the color and the color retention during storage of dried *Capsicum* powder.

Objectives:

Five objectives were taken into consideration in the study in order to adopt prior grinding, during grinding and post grinding techniques, which will be important in enhancing the degree of colour in the chillie powder and to introduce economical and low cost treatments.

1.Determination of critical moisture content liable for optimum colour retention during storage.

2.Determination of the influence of fat content of the seed on the red colour pigments of the pod.

3. Determination of the influence of non-enzymatic browning reaction on enhancing initial colour after grinding.

4.Determination on most suitable particle size of chillie powder to least colour deterioration during storage.

5.Recommendation of the most suitable and economical flexible packing material in terms of quality as well as consumer perception.

CHAPTER 2

2. LITERATURE REVIEW

2.1Composition of *Capsicum*

Capsicum fruits contain fixed (fatty) oil, pigments, pungent principles, resin, proteins, cellulose, pentosans and mineral elements (Purseglove et al., 1981).

2.2 Colour pigments

The colour of chillie is due to the presence of carotenoids, a group of pigments occurring naturally in plants. The pigment content of the dried chillies can range from about 0.1 to 0.5 percent. The pigment content of the freshly picked pod is dependent upon a number of factors, not least being the cultivar grown and the stage of maturity at harvest (Purseglove et al., 1981).

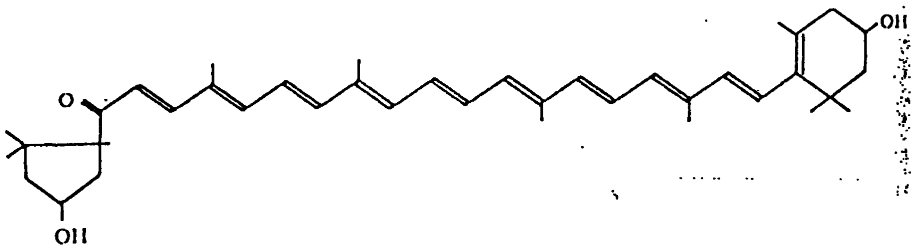
The colour of chillie is due to presence of carotenoids. The pigments have been shown to comprise of a mixture of closely related carotenoids, including cis-trans isomers, which are present in both ester and free forms. Over 30 carotenoids have been detected in some analysis but the structures of a number of these have not yet been conclusively identified (Chonky et al., 1939).

The major pigment of the red form of *C.annuum* is capsanthin, which was isolated in a crystalline form as early as 1927(Karer and Jucker, 1950), but the structure was not conclusively assigned until recently. Capsanthin is a keto-carotenoid containing a cyclopentane ring. It occurs in a concentration of about 35% of total carotenoids. Capsanthin is always found in chillies in an esterified form and occurs usually as the dilaurate (Curl, 1962)

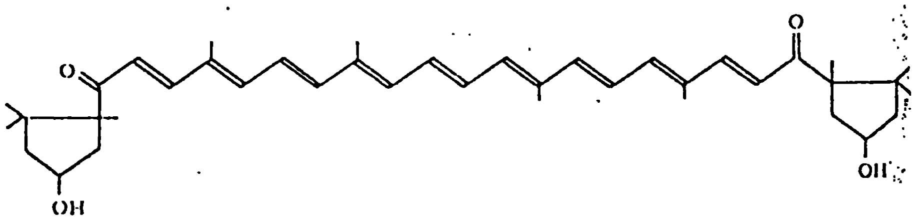
The two main contributors to the red colour in *C.annuum* cultivars are capsanthin and another Keto-carotinoid, capsorubin (Philip and Francis, 1971).

Among these carotinoids there are oxygenated ones which are usually referred to as the xanthophylls.The structures of some of the major pigments of the red forms of *C. annuum* are listed in Figure 2.1

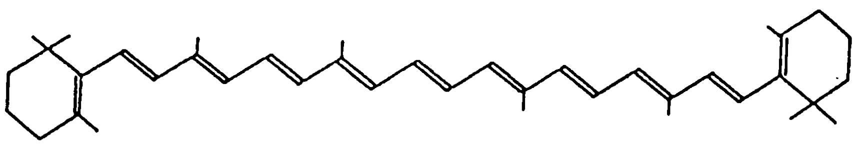
Capsanthin



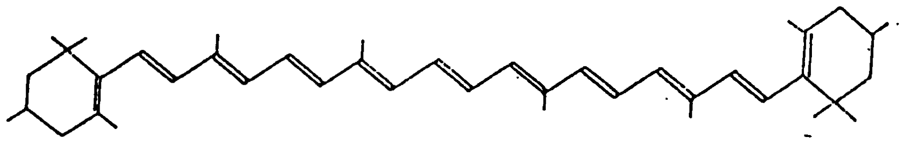
Capsorubin



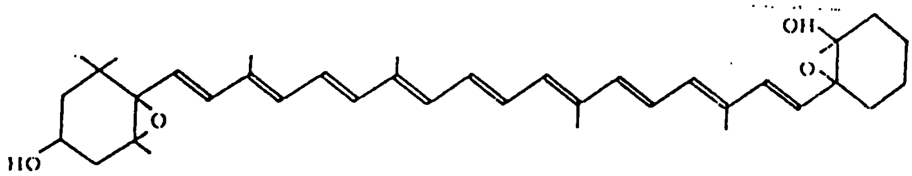
Beta-carotene



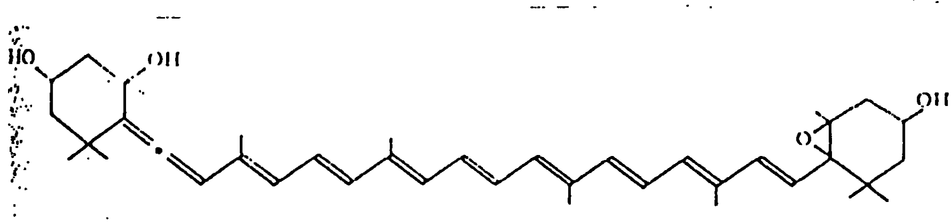
Zeaxanthin



Violaxanthin



Neoxanthin



Lutein

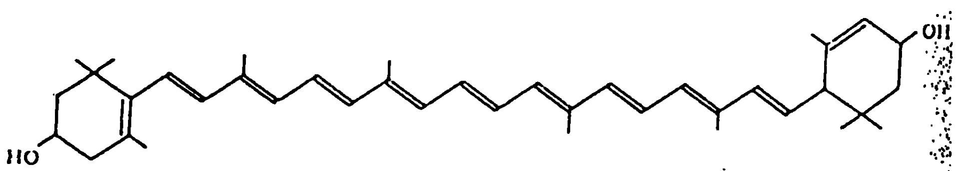


Figure 2.2 Structures of some of the major pigments in paprika and other red forms of *C. annuum*

Source: Purseglove et al., Spices (1981).

The percentages of the carotinoids are listed in table 2.1

Table 2.1 Analytical data for the pigment composition of ripe red *C. annuum* (Approximate percentage of total carotinoids)

Pigment	Percentage %
Capsanthin	32
Capsorubin	8
Beta-carotene	12
Zeaxanthin	7
Cryptoxanthin	8
Violaxanthin	10
Neoxanthin	2
Antheraxanthin	9
Cryptocapsin	5
Luteine	-

Source: Purseglove et al.,Spices (1981).

2.3 Colour deterioration

Changes in colour of the chillies take place during storage and also during processing. Some of the common observations made by processing and marketing people, are the loss of colour when chillies are exposed to sunlight and also when chillies are packed in very hot rooms. This loss of colour is due to the oxidation of the two main pigments. Chemically this is due to the hydroxyl groups followed by a break of the chain at the C-C bond with the ultimate result of forming many short form compounds (Tirimanne and Lord, 1952).

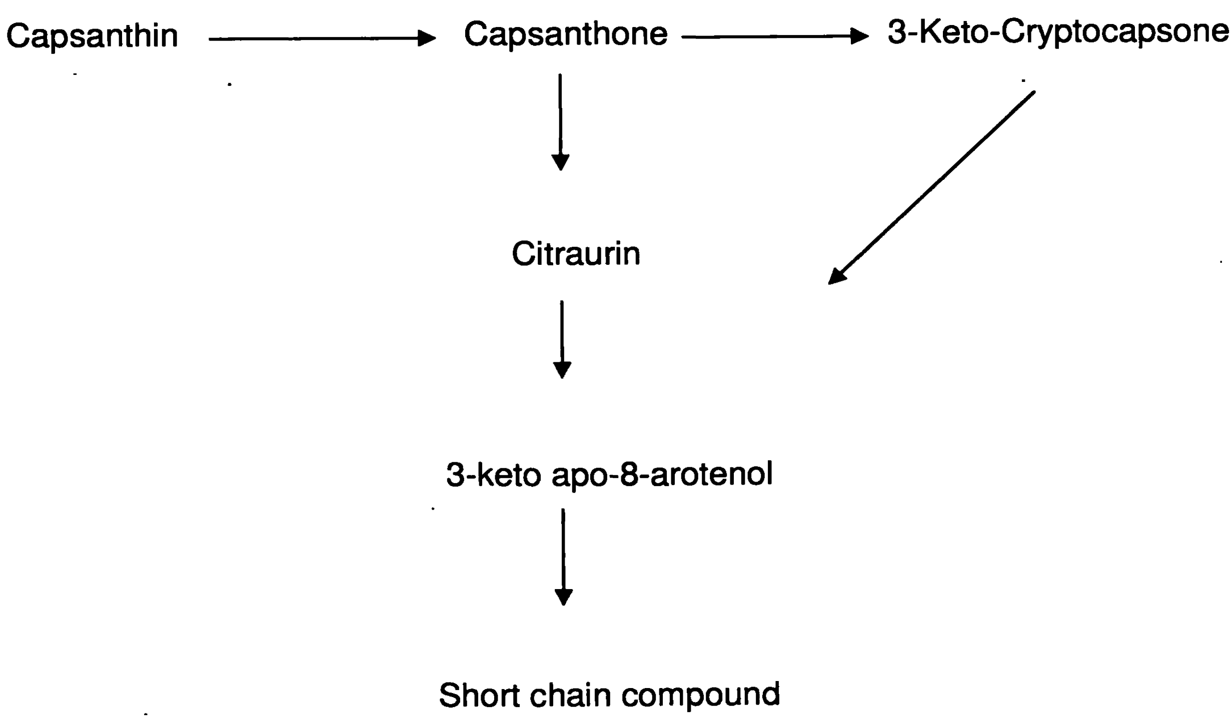


Figure 2.2 Changes in colour pigments during storage.
Souce:Purseglove et al.,Spices (1981).

The conversion to keto compounds does not alter the colour of the chillies but however once the keto compounds are formed, these are rapidly decomposed to form colourless compounds (Tirimanne and Lord, 1952).

In the alternative, these compounds may react with other compounds to give dark coloured compound (Tirimanne and Lord, 1952). Present scientific evidence seems to indicate that this reaction is very similar to the non-browning reaction. The brown components in pepper powder were determined by using absorption spectrum (Shuster and Lockhart, 1954). This was similar to that formed by non-enzymatic browning in other dehydrated vegetables (Hendel et al., 1960).

2.4 Effect of various factors influence the initial colour and colour retention properties of dried *capsicum* products

2.4.1 Temperature

The most important controllable factor affecting colour retention of the dried products during storage is the temperature.

In general, storage at a higher temperature increases the rate of colour deterioration. The blackening of whole chillies is found to increase at higher temperature, In the other hand the loss of colour is noticeably slower at lower temperatures during storage (Tirimanne andLord, 1952). Storage at 3 7^0C was found to accelerate colour loss but it paralleled that occurring at 25^0C. Refrigerated storage at 5^0C slowed the rate of deterioration but did not affect the inherent colour stability of colour of the particular *Capsicum* cultivars. On the regaining ambient temperature, the refrigerated material suffered a quicker colour loss than the corresponding unchilled material. This rapid colour loss would correspond possible with the shelf-life time of the retailer (Lease and Lease, 1956).

2.4.2 Enzymes

There is evidence to indicate that these colour changers not due to enzymatic reactions. Since autoclaving dried *capsicum* products does not have any beneficial effect on colour retention (Van Blaricom and Martin, 1951).

2.4.3 Moisture

The moisture has a very important role to play in the deterioration of the colour in chillie. The Chillie powders having moisture content of 9-10%, retained a better colour than those having a moisture content of less than7% in atmosphere (Chen and Gutamanis, 1968).

And the storage of whole chillies in sealed cans over a period of six month with a moisture content of less than 9%(Lease and Lease, 1966).

The storage of whole chillies in cans with moisture content 11.0-12.9 percent retained a higher colour, expressed as beta-carotene content, than samples with moisture contents below 9 percent (Krishnamurthy and Nataraj, 1973). They have also pointed out that whole chillies stored with moisture content of 11-12 % turned black in colour.

There is a scientific explanation for this spectroscopic evidence has shown that blackening of chillie is associated with an increase in the non-enzymatic browning reaction (Purseglove et al., 1981).

2.4.4 Light and air

Exposure of the dried spices to air and light accelerates the rate of bleaching. The maximum discolouration of the red pigments in chillies is usually brought about by sunlight. Chillie powder stored in glass bottles and in tins at 25 ^{0} C for ten months showed no significant difference in colour retention between samples in two containers. All the samples in bottles showed surface bleaching and the colour of the samples faded uniformly with time (Lease and lease, 1966;chen and Gutmanis, 1968). Light degradation of carotinoids is in direct correlation with the partial pressure of natural colour formations with antioxidants is a good way to increase light stability substantially (Purgelove et al., 1981). So storage in airtight containers out of sunlight is desirable.

2.4.5 Fat content

Pods with a high fat content are more susceptible to colour deterioration. Seven samples which retained most of the red colour had a fat content 10.0 to13.8%, while those samples which lost their colour had a fat content of 28.0 to30.8%. This hypothesis is further supported by the fact that when the samples were ground without seeds, the colour was much more stable (Van Blaricom and Martin, 1951). Also it should be noted that the fat is considered to have a beneficial action as a solvent for the pigment and aids (Chen and Gutmanis, 1968). However there appears to be an association of colour loss with rancidity and therefore with the fat. The trigrlycerides of the fat are rich in unsaturated acids, which are prone to oxidation. The mechanism for discolouration of the pigments initiated by light-catalysed oxidation of the fat (Philip and Fransis, 1971). The presence of a high amount of unsaturated fat in chillies and the fact that the pigments with are presently, as esters of fatty acids, cannot over looked in the oxidative deterioration of colour (Tirimanne and Lord, 1952). The application of at soluble antioxidants has been found to improve colour retention. Addition of antioxidants is more effective after curing than before and with the ground spice rather with whole pods (Purseglove et al., 1981). The treatment of chillie powder with "ethoxyquin"(Santoquin) afforeded both substantial protection against colour deterioration and an improvement of the surface colour during storage. The treatment was most effective in low moisture samples (Trimanne and lord, 1952).

2.4.6 State of chillie

State of chillie is another factor influences the colour retention. The colour of the ground spice deteriorates faster than whole or sliced pods on storage. But the latter quickly lose colour on eventuak grinding (Van Blarcom and Martin, 1951).

2.4.7 Other factors

The major factor influencing both initial colour and the colour retention is considered to be the cultivar grown. Next in importance is the state of maturity of the fruit harvest. Pods left to partially dry (wither) on the plant are considered to have superior colour properties to those picked when fully coloured but still succulent (Lease and Lease, 1956). The conditions employed for drying the pods can also influence initial colour retention (Lease and Lease, 1962).

2.5 Packaging

2.5.1 Importance of packaging

The main aims of packaging are to keep foods in good condition (to give them their expected shelf life) and to encourage customers to buy the food. For many the success of a small business depends on the type and cost of available packing. Correct packing extends the shelf life of food, which allows it to be distributed to more distant markets. Good packaging also attracts customers to buy a product in preference to competitor's brands and can develop an image of quality or value for money, so that people buy the same products again. Food with a longer expected shelf life have different needs and may require more sophisticated packaging to protect them against air, light, moisture, crushing, insect or micro-organism.

2.5.2 Spices

Spices and spice products are hygroscopic in nature, and being highly sensitive to moisture, their absorption of moisture may result in caking, discolouration, hydrolytic rancidity, mold growth, and insect attack. Furthermore, since spice contains volatile aromatic principles; the loss of these principles and the absorption of foreign odour as a result of inefficient packaging may pose serious problems, especially in ground spices. In addition, heat and light accelerate deterioration, especially with oxygen sensitive products. In the case of chillie powder, packaging material plays important role in colour deterioration.

2.5.3 Ground chillie

Ground chillie, because of the greater surface area exposed, lose flavour faster as a result of volatile oil, and they absorb or lose moisture faster, depending on the atmospheric humidity surrounding them and the storage temperature. Thus they deteriorate much more rapidly than do whole chillie.

2.5.4 Importance barrier properties need to colour retention

Ground chillie needs protection against light; ingress of moisture and oxygen. The colour of *capsicum* is mostly due to carotenoids, which are susceptible to oxidative deterioration in the presence of light. Therefore, ground chillie need special attention in packaging to protect them against such rapid deterioration (Arthur, 1991). In packaging material, too, the barrier has this dual function of prohibiting entry in to and escapes from the interior of the package. In the case of the oxygen barrier, the primary function is that of excluding the gas from the package content. However in the case of the moisture barrier, the packaging material may be required to maintain the moisture content at either a low or high level. The packaging must exclude the migration of even traces of moisture over the expected storage life of product. The need for oxygen barrier varies with its normal life expectancy. Oxygen may also contribute to the dete1rioration of the product by chemical means. Oxidation of fats and oils leads to rancidity. Even minute amounts of oxygen which would penetrate the barrier would set off rancidity in the presence of light (Arthur, 1991).

2.5.5 Types of packing materials

2.5.5.1 Low-density polyethylene (LDPE)

Black master and white master chemically make LDPE packing material. It has low moisture, light and oxygen barrier properties. But it has high sealing property.

2.5.5.2 Laminate pack (OPP/MPET/LDPE)

This packing material contains three layers. These are,

1.OPP (Oriental polypropylene)

2.MPET (Metallize polyethylene terephthalate)

3.LDPE (Low density polyethylene)

Thickness of the material is 0.10mm.

Aluminum metallized films are extensively used in food packaging applications. Many types of films can be metarllize; for example, polyethylene terephthalate(PET) and polypropylene(PP) are used extensively on a commercial basis, and PET has largest share in the metallized film market. Normally a 12-micron film of PET is metallized with an aluminum layer composed of 0.03-0.05

micron. The thickness of the metal layer, and therefore the barrier properties of the film, are usually measured by optical density since metal is opaque to light. The higher barrier metallzed PET is used to make pouches for snacks, chocolates and coffee. For these applications metalliezed PET is laminated to a thermosealable film (PE, PP), but when barrier properties are a must, it is useful to metallize the film on both sides (Pedro et al.,1981).

Table 2.2 Permeability (as) of single film to water and moisture

Polymer structure	Permeability (P) to O_2	Permeability (P) to moisture
LDPE	31	1200
PET-met	0.005	58

Source: Pedro et al., 1981

2.6 Sensory evaluation

Definition: - Sensory evaluation is a scientific discipline used to evoke, measure and interpret reactions to the characteristics of foods and materials as they are perceived by the sense (Stone et al.,1983).

The production of finished foods, either by the farmer or the food processor, implies that the consumer will accept these products and pay the requisite price that the product has a certain quality. It is easier to recognize quality than to define it. Quality is obviously some sort of mental summation of the physical and chemical properties of the food. Many sensory factors are involved. But the relation of each to although can be correlated with sensory tests. In order to determine differences between food variety of sensory testing procedures have been developed. These are used to select sensitive panels, to insure uniform quality, or to defect the difference in food quality between processes, raw materials, or storage conditions (Amerome, A.M., 1973).

2.6.5 Rating test

Definition:- Method of classification involving categories. Each category is composed of an ordered scale. The points on each scale are of an ordinal nature.

Applications:- Rating test is recommended for use as a means of evaluating.

a) The intensity of one or more attributes
b) The degree of preference

Assessors:-For determination of intensity of attributes,

1or more experts

5 or more selected assessors

20 or more assessors

Analysis of data: -When more than one sample is rated, a non-parametric method should be used to compare the distribution obtained (SLS: 931) .

CHAPTER 3
3.MATERIALS AND METHOD

3.1 Sample preparation

3.1.1 Materials

1.Chillie pods (*Capsicum annuum* -3kg
*2.*Chillie seeds -500g
3.Packing materials
a). Laminate pack (PET/METPET/LDPE)
b). LDPE pack
4). Equipments
-Pin mill
-Moisture meter
-Polysealer
-Panthan colour chart
-Decicator

3.1.2 Methodology

Primary objective of this study was to determine the factors responsible for colour change of ground chillie powder. Thus, fully matured well-ripened and dried chillie pods were subjected for this experiment with the view to measure behaviour of visual sense of the product with respect to the design of experiment in the factorial design.

In the factorial experiment effect of two or more factors were investigated simultaneously. Treatments were called factors. In this experiment, five factors with two levels (high and low) were investigated to determine interaction or differential effect of one factor at two levels of the other factor.

Five most influential variables with two levels such as moisture content, seed pericarp ratio, exposure time, particle size and packing material pertaining to the colour changes of chillie powder were used in this study. These variables were,

- a). Moisture Content
  - High level at 12%-a_0
  - Low level at 8% -a_1
- b). Seed: Pericarp Ratio
  - High seed (1:1) –b_0
  - Low seed (1:2) –b_1
- c). Particle Size
  - Fine particles (250µm) - c_0
  - Coarse particles (500µm) -c_1
- d). Exposure Time
  - Without exposure -d_0
  - With over night exposure –d_1
- e). Packing material
  - Low barrier pack (LDPE) –e_0
  - High barrier pack -e_1 (Laminate PET/METPET/LDPE)

32-treatment combinations (samples) with respect to the statistical design 2-factor factorial design were prepared and each treatment was replicated three times.

3.1.2.1 Preparation of treatment combinations

(1). Preparation of chillie powder at two moisture level [a_o and a_1]:-

3kg of chillie pods were subjected for around 1 and 6 hrs drying process in order to get moisture content 12% [a_o] and 8% [a_1] respectively. Moisture content of the samples was detected by SLS: 186 methods.

(2). Preparation of seed pericarp ratio at two levels [b_0 and b_1] :-

Seed content in the mixture was changed to get different levels of fat content. For instance, high amount of seed or fat content was mixed with chillie powder in order to get high seed pericarp ratio.

(3). Preparation of chillie powder with two types of particle size [c_0 and c_1] :-

Chillie pods were ground by a pin miller. Two meshes were used to get two levels of particle size in chillie powder mixture. The particle size was determined by using HML standard method.

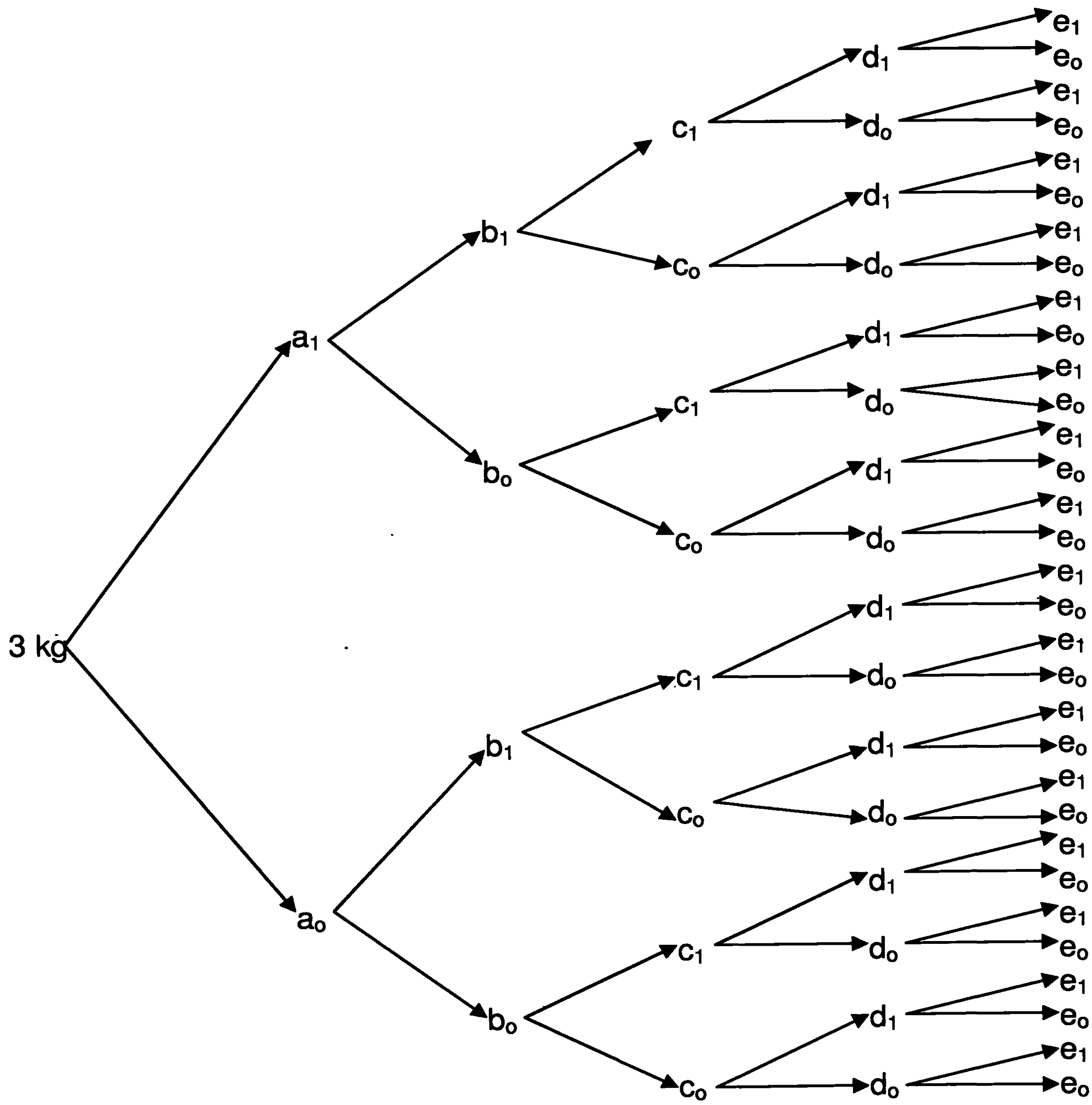
(4). Preparation of chillie powder at two different exposure levels [d_o and d_1]:-

chillie powder was spreaded over a polythene layer and exposed to environment over night under control condition. Special attention was taken to avoid moisture content changes.

(5). Packing of chillie powder with two flexible packing materials at two barrier levels [e_o and e_1];-

High barrier properties to light and air were obtained by using laminate pouches to pack. The low level was obtained by using low barrier packaging material called LDPE.

Samples were prepared with respect to the design given below, with incorporation of chillie powder subjected for different treatments.



a_o - high moisture 12%
a_1 - low moisture 8%
b_o - seed pericarp ratio 2:1
b_1 - seed pericarp ratio 1:1
c_o - fine particles
c_1 - coarse particles

d_o - without exposing
d_1 - with exposing
e_o - LDPE pack
e_1 - laminate pack

Figure 3.1 Preparation of treatment combinations

Table 3.1. The treatment combinations according to factorial design.

Sample No.	Treatment combination
1	$a_0b_0c_0d_0e_0$
2	$a_1b_0c_0d_0e_0$
3	$a_0b_1c_0d_0e_0$
4	$a_1b_1c_0d_0e_0$
5	$a_0b_0c_1d_0e_0$
6	$a_1b_0c_1d_0e_0$
7	$a_0b_1c_1d_0e_0$
8	$a_1b_1c_1d_0e_0$
9	$a_0b_0c_0d_1e_0$
10	$a_1b_0c_0d_1e_0$
11	$a_0b_1c_0d_1e_0$
12	$a_1b_1c_0d_1e_0$
13	$a_0b_0c_1d_1e_0$
14	$a_1b_0c_1d_1e_0$
15	$a_0b_1\ c_1d_1e_0$
16	$a_1b_1c_1d_1e_0$
17	$a_0b_0c_0d_0e_1$
18	$a_1b_1c_0d_0e_1$
19	$a_0b_1c_0d_0e_1$
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25	$a_0b_0c_0d_1e_1$
26	$a_1b_0c_0d_1e_1$
27	$a_0b_1c_0d_1e_1$
28	$a_1b_1c_0d_1e_1$

29	$a_0b_0c_1d_1e_1$
30	$a_1b_0c_1d_1e_1$
31	$a_0b_1c_1d_1e_1$
32	$a_1b_1c_1d_1e_1$

3.2 Determination of moisture content

3.2.1 Apparatus and reagent

1.Toluene

2.Distillation apparatus, comprising the following components fitted together by means of ground glass joints.

3.Flask, short necked, at least 500ml

4.Reflux condenser

5.copper wire: This should be long enough to extend through the condenser with one end twisted into a spiral. The diameter of the spiral should be such that it fits snugly within the graduated portion of the receiver and yet can be moved up and down.

3.2.2 Procedure

Sample of 0.01g of prepared was weighed and 4.5ml of water were measured accurately. The weighed portion was transferred quantitatively to the distillation flask with toluene. Sufficient toluene (about 75ml in all) was added to cover the sample completely and swirled to mix. Apparatus were assembled and filled the receiver with the solvent by pouring it through the condenser until it begins to overflow into the distillation flask. Loose cotton plug was inserted at the top of the condenser tube. In order that the refluxing was controlled by wrapping the flask and tube leading to the receiver with asbestos cloth.

The flask was heated until distillation rate was about 100 drops per minute. When the greater part of the water distilled over, the distillation rate was increased to about 200 drops per minute and continued until no more water was collected. Reflux condenser was purging occasionally moving a spiral copper wire up and down in the condenser. The source of heat was turned off after the water level remained constant for 30 minutes. The condenser with toluene was flushed as required, making use of spiral copper wire to discharge any moisture droplets.

The receiver was immersed in water at room temperature for at least 15 minutes or until the toluene layer was clear, then the volume of water was read (SLS: 186).

3.3 Determination of particle size

3.3.1 Apparatus

1. Sieves (500 µm or 250 µm)
2. Mechanical shaker
3. Electric balance

3.3.2 Procedure

Chillie powder of 100g was weighed accurately and placed it evenly on a sieve of aperture 500 µm or 250 µm. It was shaked by suitable mechanical shaker for 15 minutes. The material that passed though the sieve was weighed, the particle size was assumed as sieve aperture size, if 60% of the material passed through the sieve (HML standard method).

3.4 Sensory evaluation

3.4.1Screening test (selecting a sensory panel)

The visual sense of sensory panel was taken as main parameter to determine colour changes during storage. Thus selecting the sensory panel to avoid biasness due to red blindness was essential. Since members of sensory panel were selected from screening test. Five different red colours were given to ten persons to range in ascending order. Six members who accurately selected colours in correct range were taken as sensory panel (Appendix 1).

3.4.2 Sensory test

The result was gathered from the trial on colour by means of visual sense, within three-week period, after forming a sensory panel. A rating test used for this experiment. Each category was composed of an ordered scale (Appendix 11).

3.4.3 Data analyzing

Data generated from sensory evaluation were analyzed by the statistical methods using Non Parametric Technique (Friedman test).

CHAPTER 4

4. RESULT AND DISSCUSSION

4.1 Collected data from sensory evaluation

Samples prepared with different treatments were subjected to sensory evaluation in order to assess changes of colour during period of four and half mounths. The mean value of the selected six panelist observations are given in table 4.1

Table 4.1 Mean values of sample observations

Sample No	3nd week	6th week	9th week	12th week	15th week
1	7.16	5.50	5.33	4.50	3.66
2	7.40	6.00	5.80	4.86	3.99
3	7.33	6.16	4.50	4.33	3.83
4	7.50	6.50	6.00	5.16	4.00
5	7.33	6.16	5.00	4.50	3.83
6	7.50	6.33	5.00	4.83	4.00
7	7.66	6.50	6.16	5.16	4.16
8	7.92	6.75	6.45	5.75	5.00
9	8.16	8.00	3.33	2.50	2.16
10	8.66	8.33	7.92	3.00	2.80
11	8.50	8.50	8.00	3.33	2.16
12	8.83	8.66	7.16	5.33	4.50
13	8.00	7.50	7.00	5.00	4.66
14	9.00	8.83	8.66	5.33	5.00
15	8.83	7.92	3.33	2.66	2.16
16	9.16	9.00	8.16	7.66	6.50
17	7.33	7.00	7.00	6.75	6.45
18	7.92	7.16	7.00	6.83	6.66
19	7.50	7.00	6.83	6.66	6.50
20	7.92	7.66	7.16	7.00	6.83

21	7.83	7.66	7.50	7.33	7.00
22	8.00	7.83	7.50	7.16	7.16
23	8.33	7.92	7.83	7.50	7.50
24	8.50	8.33	8.33	8.00	7.92
25	9.16	8.00	7.66	7.16	7.16
26	9.00	9.00	8.50	8.00	8.00
27	9.33	9.00	9.00	8.50	8.16
28	9.50	9.50	9.33	9.33	8.83
29	9.00	8.83	8.16	8.16	8.00
30	9.50	9.33	9.16	9.16	9.00
31	9.66	9.50	9.50	9.33	9.16
32	9.83	9.66	9.66	9.50	9.50

4.2Analysis results of sensory evaluation for 32 treatment combinations

H_0 =There is no significant different between chillie powder samples at 5% level.
H_1= There is significant different between chillie samples at 5% level.

According to results gathering from friedman test, the P value is less than 0.05.Ho is rejected. H1is accepted. Since there is significant different in colour changes occur in 32 samples during storage. $a_1b_1c_1d_1e_1$ sample scored highest average rank from the friedman test. So this sample is selected as best coloured sample. It contains 8% moisture level and high seed level. Fine particles are subjected to expose over night. It stored in laminate packs. These are high levels of the factors in the factorial design. Since the entire five factor combinations were effected on the colour of chillie powder. Such as moisture content, particle size, exposure, seed pericarp ratio and packing material. Therefore, high levels of factors are suitable for colour improvement and the colour retention during storage of chillie powder (For analysis result of sensory evaluation refer Appendix III)

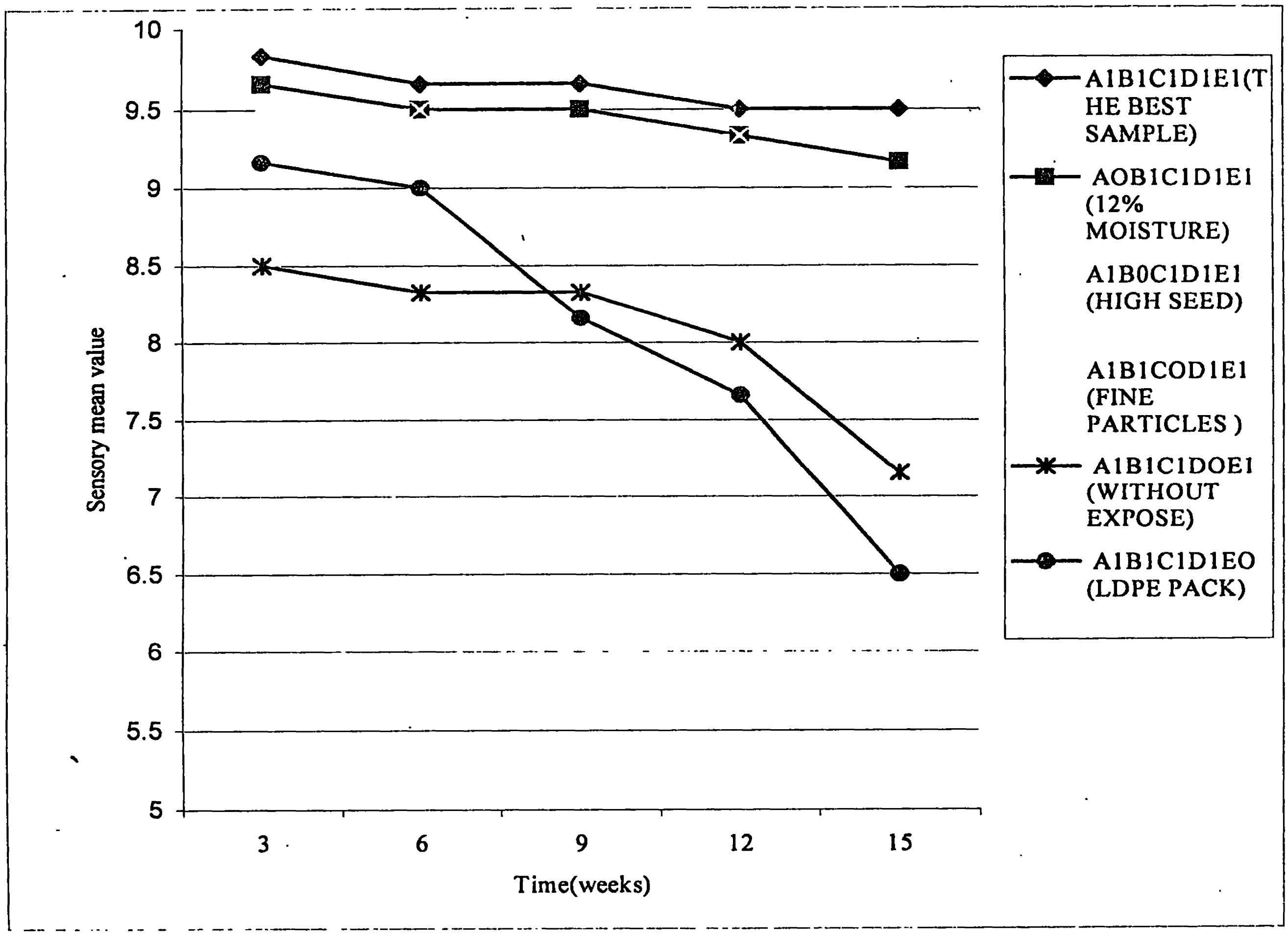

Figure 4.1 Mean values of samples during storage

4.2.1 Effect of moisture obtained by sensory evaluation

The $a_0b_1c_1d_1e_1$ sample contained low level of moisture and other factors were optimum. It reduced the colour from 9.66 to 9.16 .The difference of the colour was 0.5. But best sample which contained factors in optimum levels reduced from 9.83 to 9.50. The change of colour was 0.33.The different observations of these two samples were only due to moisture content. Other factors were constant. Since the chillie powder having moisture content 8%, retained a better colour than those having moisture content of 12% in the sealed environment. Since dried chillie pods that were received from the market were not suitable for direct grinding. Because dried chillie pods approximately had around 12 % moisture in normal environment conditions. Normally processors can reduce the moisture content from 12% to8% by sun drying within one day. Therefore, the process of the chillie powder preparation should be done without rainy and high humidity conditions in order to retain the moisture content within 8% level. From these studies it was confirmed that 8% moisture content achieved better colour during storage.

4.2.2 Effect of seed content obtained by sensory evaluation

According to the graph, the $a_1b_0c_1d_1e_1$ sample had reduced colour from 9.50 to 9.00. The difference of the colour observation was 0.5. But the best sample that contained factors in optimum level had reduced the colour by 0.33. Only difference of these samples was amount of seed content in the powder. Best sample contained a low level of seeds. Since seed content of the chillie powder played a main role with regard to colour in the experiment, the amount of the seeds affected the initial colour. The low seed content samples were given higher colour than the high-level seed samples, because seeds are contained less amount of colouring pigments. On the other hand, chillie powder with high fat content was more susceptible to colour deterioration. This was proved by the fact that when the samples were ground with low seeds, the colour was more stable.

4.2.3 Effect of particle size obtained by sensory evaluation

The $a_1b_1c_0d_1e_1$ sample had reduced colour from9.00 to 8.00 .The difference of colour observation was 1.00. But best sample had reduced by 0.33. Only difference of these samples was the particle size. The best sample contained coarse particles. Since the particle size of the chillie powder influences the colour retention during storage, fine powder deteriorates the colour pigments faster than the coarse one.

4.2.4 Effect of exposure time obtained by sensory evaluation

The $a_1b_1c_1d_0e_1$ sample had reduced colour from 8.50 to 7.92 .The difference of the colour observation was 0.58.But best sample had reduced by 0.33. The best sample was exposed to the air under control conditions. This sample was not subjected to exposure. Since the best sample had 9.83 mean value at the beginning. It was greater than 8.50. Therefore exposing treatment highly affected at the initial colour improvement. Present scientific evidence seems to indicate that this reaction is very similar to the non-browning reaction.

4.2.5 Effect of packing material

The $a_1b_1c_1d_1e_0$ sample had reduced colour from9.16 to 6.50. The difference of the colour observation was 2.66.It was greater than 0.33.But this sample had 9.16 mean value to the colour at the beginning. This colour had deteriorated faster than the best sample. Only difference of these samples was the packaging material. Since packing material plays the main role in colour preventing, the packing material affects on colour retaining than the other treatments in the experiment. The best sample was packed in laminate pouches. Laminate packing material has acted as the light, air and moisture barrier.

Other factors affecting colour pigments were not considered in this experiment. Temperature was mainly affected to the colour deterioration. But controlling temperature during storage was not practicable and economical. Normally processors received dried chillie pods from the market. Since factors affecting before grinding were not considered in this experiment, uniform samples were subjected to this experiment under same environmental conditions to avoid biasness from the other factors.

Colour measurements of chillie varieties were normally done by spectrometric methods. These methods are economically valuable, but accurate. In this study, visual sense was used as colour detection parameter, when perceiving chillie powder from the market. So sensory evaluation was better to detect colour in chillie powder.

CHAPTER 5

5.CONCLUSION AND RECOMMONDATION

According to the findings the study, the colour of chillie powder is affected by seed content, packing material, exposure time particle size of the chillie powder and the moisture content of the powder during storage.

Colour deterioration of chillie powder can be mainly avoided by packing material. Laminate pouches are sustainable to store chillie powder with protection against light, air and moisture.

Exposing chillie powder to environment over night is effective physical treatment to increase the colour and this colour improvement retains during storage.

High seed containing chillie powders are highly subjected to the colour deterioration during storage.

Fine particles of the powder deteriorate faster than the coarse particles.

From these studies it was confirmed that 8% moisture content achieved better colour than 12% moisture content.

Further studies and recommendations: -

Further studies must be done to determine optimum exposure time to get optimum colour improvement without reducing pungency, and also study on the determination of the reaction occurs during the exposing time. Steps should be taken to expose chillie powder to air over night under controlled conditions in order to enhance the colour.

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APPENDIX I

SCREENING TEST

Date :-

Name :-

Please rank given colors according to increasing the red color in ascending order.

Panthan color number	Ranking number
1777U	
1787U	
032U	
1797U	
1807U	

APPENDIX II

SENSORY TEST

Date :-

Name :-

Please select number for each 32 samples according to red brightness.

Pale red □ Bright red

Sample 1

1	2	3	4	5	6	7	8	9	10

Sample 2

1	2	3	4	5	6	7	8	9	10

Sample 3

1	2	3	4	5	6	7	8	9	10

Sample 4

1	2	3	4	5	6	7	8	9	10

Sample 5

1	2	3	4	5	6	7	8	9	10

Sample 6

1	2	3	4	5	6	7	8	9	10

Sample 7

1	2	3	4	5	6	7	8	9	10

Sample 8

1	2	3	4	5	6	7	8	9	10

Sample 9

1	2	3	4	5	6	7	8	9	10

Sample 10

1	2	3	4	5	6	7	8	9	10

Sample 11

1	2	3	4	5	6	7	8	9	10

Sample 12

1	2	3	4	5	6	7	8	9	10

Sample 13

1	2	3	4	5	6	7	8	9	10

Sample 14

1	2	3	4	5	6	7	8	9	10

Sample 15

1	2	3	4	5	6	7	8	9	10

Sample 16

1	2	3	4	5	6	7	8	9	10

Sample 17

1	2	3	4	5	6	7	8	9	10

Sample 18

1	2	3	4	5	6	7	8	9	10

Sample 19

1	2	3	4	5	6	7	8	9	10

Sample 20

1	2	3	4	5	6	7	8	9	10

Sample 21

1	2	3	4	5	6	7	8	9	10

Sample 22

1	2	3	4	5	6	7	8	9	10

Sample 23

1	2	3	4	5	6	7	8	9	10

Sample 24

1	2	3	4	5	6	7	8	9	10

Sample 25

1	2	3	4	5	6	7	8	9	10

Sample 26

1	2	3	4	5	6	7	8	9	10

Sample 27

1	2	3	4	5	6	7	8	9	10

Sample 28

1	2	3	4	5	6	7	8	9	10

Sample 29

1	2	3	4	5	6	7	8	9	10

Sample 30

1	2	3	4	5	6	7	8	9	10

Sample 31

1	2	3	4	5	6	7	8	9	10

Sample 32

1	2	3	4	5	6	7	8	9	10

APPENDIX III

Friedman Test

Friedman test for RESPONCE by TRT blocked by BLOCK

S = 125.93 DF = 31 P = 0.000

S = 126.19 DF = 31 P = 0.000 (adjusted for ties)

TRT	N	Est Median	Sum of Ranks
1	5	5.345	18.5
2	5	5.747	30.5
3	5	5.089	22.0
4	5	5.962	42.5
5	5	5.626	25.0
6	5	5.439	33.5
7	5	6.085	47.0
8	5	6.459	59.5
9	5	3.883	38.0
10	5	7.264	68.5
11	5	7.247	67.5
12	5	7.115	85.5
13	5	6.929	67.0
14	5	7.903	103.5
15	5	3.893	43.5
16	5	8.182	118.5
17	5	6.949	58.5
18	5	7.061	73.0
19	5	6.872	61.0
20	5	7.271	80.0

21	5	7.493	84.0
22	5	7.514	89.5
23	5	7.816	99.5
24	5	8.282	113.5
25	5	7.741	107.0
26	5	8.507	129.0
27	5	8.890	139.0
28	5	9.319	149.5
29	5	8.391	125.5
30	5	9.192	146.5
31	5	9.490	154.0
32	5	9.653	160.0

Grand median = 7.144

Friedman Test

Friedman test for RESPONCE by BLOCK blocked by TRT

S = 121.74 DF = 4 P = 0.000

S = 124.87 DF = 4 P = 0.000 (adjusted for ties)

BLOCK	N	Est Median	Sum of Ranks
1	32	8.363	158.5
2	32	7.797	127.0
3	32	7.333	97.0
4	32	6.738	63.0
5	32	6.374	34.5

Grand median = 7.321