

# **Studies to assess the health benefits of selected small millet products**

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**Scaling up Small Millet Post-harvest and Nutritious Food  
Products Project**

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## Studies to assess the health benefits of selected small millet products

To enhance utilization of small millets for all age groups the TNAU has taken up the following activities as part of the project: 1) Developing multi millets based therapeutic foods, 2) Developing multi-millet based food products and 3) Carrying out anti-diabetic and bioavailability studies. The following sections give a detailed account of these activities.

### Developing therapeutic products suitable for diabetic, obesity, cardio vascular diseases

#### Multi millets based therapeutic foods and assessing consumer acceptance

Therapeutic foods are designed for specific, usually nutritional, therapeutic purposes as a form of dietary supplement. Therapeutic foods that are developed to suit the dietary pattern during physiological disorder, which will also provide require nutrients. The following multi millets based therapeutic foods suitable for breakfast and lunch were developed and standardized.

- Multi millet Therapeutic foods suitable for breakfast
  - Drumstick leaves *dosa* mix
  - Fenugreek leaves *dosa* mix
  - Drumstick leaves *chappathi* mix
  - Fenugreek *chappathi* mix
  - Vegetable *rotti* mix
  - *Kitchadi* mix
  - Palak leaves *dosa* mix
  - *Upma* mix
  - *Idiyappam* mix
  - *Adai* mix
- Therapeutic foods suitable for lunch
  - Palak rice mix
  - Methi rice mix

Instant mixes of these therapeutic food products with the incorporation of multi millets (kodo millet/ little millet/ barnyard millet/ foxtail millet) were standardized. The millet grains were cleaned to remove the dust, dirt, chaff and stones by winnowing, sieving and dehulling. The cleaned millet rice was dried in the sun by spreading uniformly for 5 – 6 hours and used for the preparation of instant rice mixes. The dried millet rice was then pulverized to obtain flour. Wheat flour and rice was the major ingredients in the selected food products and that was replaced with multi millets for the development of instant

mixes. The proportion of rest of ingredients in the instant mixes were maintained as same as that of traditional method of preparation.

In the preparation of *dosa* mix, multi millets were used and to enrich the nutraceutical properties and therapeutic value, fenugreek and drumstick leaves were added in dried powder form. Similarly for palak rice and methi rice, multi millets with dried methi /palak were added.

For the preparation of Palak leaves rice and Methi leaves rice whole dehulled millets were used as such. Drumstick leaves/ Fenugreek leaves *chappathi*, Vegetable *rotti*, *Idiyappam*, Drumstick leaves/ Fenugreek leaves *dosa*, Palak leaves *dosa* and *Adai* were prepared using flour of multi millets. For *Kitchadi* and *Upma* grits of multi millets were used. The products were standardized and evaluated for their sensory attributes by a panel of trained members using a nine point hedonic scale and assessed the nutrient content of these foods. The sensory score were presented in the Table 1.

**Table: 1 Sensory score of multi millet based therapeutic food products**

| Characteristics                                  | Colour | Flavor | Texture | Taste | Overall acceptability |
|--|--------|--------|---------|-------|-----------------------|
| Multi millet palak leaves rice mix               | 9.0    | 9.0    | 9.0     | 9.0   | 9.0                   |
| Multi millet fenugreek leaves rice mix           | 9.0    | 9.0    | 8.9     | 9.0   | 8.8                   |
| Multi millet <i>upma</i> mix                     | 9.0    | 9.0    | 8.7     | 9.0   | 8.9                   |
| Multi millet <i>idiyappam</i> mix                | 9.0    | 8.8    | 8.5     | 8.8   | 8.8                   |
| Multi millet <i>adai</i> mix                     | 9.0    | 9.0    | 8.9     | 8.9   | 8.9                   |
| Multi millet drumstick leaves <i>dosa</i> mix    | 9.0    | 9.0    | 8.9     | 9.0   | 9.0                   |
| Multi millet based drumstick leaves chapatti mix | 9.0    | 9.0    | 9.0     | 9.0   | 9.0                   |
| Multi millet vegetable <i>rotti</i> mix          | 8.8    | 8.9    | 9.0     | 9.0   | 8.9                   |
| Multi millet <i>kitchadi</i> mix                 | 8.9    | 8.8    | 8.5     | 9.0   | 8.9                   |
| Multi millet palak leaves <i>dosa</i> mix        | 8.8    | 8.9    | 8.9     | 9.0   | 8.9                   |

The sensory score revealed that all the products from multi millet were on par with control and had the maximum acceptable score



**Fig 1: Multi millet therapeutic products**

### Nutritive value of multi millet based therapeutic foods

The developed and standardized products were analysed the nutrient content viz. carbohydrate, protein, fat, crude fibre, calcium, iron and beta carotene content by using standard procedure and presented in the Table 2.

**Table: 2 Nutritive value of multi millet based therapeutic foods (per 100 g)**

| Sl. No | Item  | Energy (Kcal) | Carbohydrate (g) | Protein (g) | Fat (g) | Crude fibre (g) | Calcium (mg) | Iron (mg) | Beta carotene ( $\mu$ g) |
|--------|---|---------------|------------------|-------------|---------|-----------------|--------------|-----------|--------------------------|
| 1.     | Multi millet based drumstick leaves <i>dosa</i> mix | 309.90        | 60.54            | 11.99       | 2.22    | 10.12           | 132.60       | 4.07      | 215.03                   |
| 2.     | Multi millet based drumstick leaves chapatti mix    | 316.91        | 64.07            | 10.08       | 2.36    | 4.64            | 41.76        | 4.21      | 125.57                   |
| 3.     | Multi millet based vegetable <i>rotti</i> mix       | 242.27        | 51.22            | 6.13        | 1.71    | 4.05            | 64.73        | 2.69      | 262.75                   |
| 4.     | Multi millet <i>kitchadi</i> mix                    | 213.73        | 38.91            | 6.14        | 4.07    | 4.94            | 37.58        | 2.97      | 291.84                   |
| 5.     | Multi millet palak leaves <i>dosa</i> mix           | 309.08        | 58.59            | 12.70       | 2.67    | 5.67            | 77.39        | 3.87      | 191.97                   |
| 6.     | Multi millet palak leaves rice mix                  | 240.15        | 37.16            | 6.36        | 7.50    | 4.65            | 44.38        | 3.00      | 910.83                   |
| 7.     | Multi millet fenugreek leaves rice mix              | 244.61        | 37.76            | 6.82        | 7.54    | 4.74            | 105.56       | 3.14      | 395.02                   |

|     |                                   |        |       |       |      |      |        |      |        |
|-----|-----------------------------------|--------|-------|-------|------|------|--------|------|--------|
| 8.  | Multi millet <i>upma</i> mix      | 285.22 | 43.21 | 6.43  | 9.63 | 5.29 | 43.27  | 4.00 | 159.53 |
| 9.  | Multi millet <i>idiyappam</i> mix | 316.74 | 64.94 | 8.19  | 2.72 | 6.84 | 85.16  | 4.00 | 130.91 |
| 10. | Multi millet <i>adai</i> mix      | 312.84 | 59.58 | 13.26 | 2.41 | 4.80 | 124.64 | 4.37 | 194.96 |

Multi millet based developed products contains high amount of protein (6.13g - 13.26g), crude fibre (4.05- 10.12g), calcium (37.58 – 132.36 mg) and beta carotene (191.97 - 291.84 µg) content. Incorporation of drumstick leaves, Palak leaves, Fenugreek leaves, increased the Beta. Carotene, fiber content and Protein content, where as the carbohydrate content reduced which is an indication that it is suitable for diabetics and other life style disorders.

**Table: 3 Microbial load of Therapeutic foods**

| Sl. No. | Samples  | Yeast and Mold | E. Coli | Total plate count  | Remarks                 |
|---------|--|----------------|---------|--------------------|-------------------------|
| 1       | Multi millet drumstick leaves <i>dosa</i> mix      | Nil            | Nil     | $3.09 \times 10^5$ | Within the safer limits |
| 2       | Multi millet drumstick leaves <i>chappathi</i> mix | Nil            | Nil     | $2.04 \times 10^5$ | Within the safer limits |
| 3       | Multi millet vegetables <i>rotti</i> mix           | Nil            | Nil     | $2.77 \times 10^5$ | Within the safer limits |
| 4       | Multi millet <i>kitchadi</i> mix                   | Nil            | Nil     | $5.04 \times 10^5$ | Within the safer limits |
| 5.      | Millet millet palak leaves <i>dosa</i> mix         | Nil            | Nil     | $2.31 \times 10^5$ | Within the safer limits |
| 6.      | Multi millet palak leaves rice mix                 | Nil            | Nil     | $2.77 \times 10^5$ | Within the safer limits |
| 7.      | Multi millet fenugreek leaves rice mix             | Nil            | Nil     | $4.59 \times 10^5$ | Within the safer limits |
| 8.      | Multi millet <i>upma</i> mix                       | Nil            | Nil     | $3.04 \times 10^5$ | Within the safer limits |
| 9.      | Multi millet <i>idiyappam</i> mix                  | Nil            | Nil     | $4.27 \times 10^5$ | Within the safer limits |
| 10.     | Multi millet <i>adai</i> mix                       | Nil            | Nil     | $4.13 \times 10^5$ | Within the safer limits |

The standardized products packed in packaging had safer limits of microbial load.

#### Bioavailability studies of multi millet based therapeutic foods

Bioavailability study of millet product was conducted in Wistar albino rats. The rats weighted around 200-300g were taken and placed at random and allocated to treatment groups in Polypropylene cages and paddy husk as bedding. Animal care procedure and experimental protocol were approved by the Institutional Animal Ethics Committee (IAEC), Karpagam University, Coimbatore, India. (Annexure IV) From the first day of the study, the animal's temperature  $24^{\circ}\text{C} \pm 2^{\circ}\text{C}$  and relative humidity of 30-70% following 12:12 light: dark cycle. All the animals provided with free access to water and standard pellet laboratory animal diet (Annexure IV).

## Development of multi millet based food products

Millets are amazing grain offering great opportunities for diversified utilization and value addition. Millets are rich sources of protein, dietary fiber, energy and minerals when compared to rice. Millet based products are gaining more attention due to health conscious in the urban areas. In order to improve the market of small millets there is a need to develop diversified products of small millet products to satisfy the consumer needs. With this back ground multi millet based products were developed and assessed its acceptability. Multi millets can be used for the preparation of traditional recipes, pasta products, extruded and expanded foods, bakery products and instant food mixes. Nutritional qualities were identified and utilized for the standardization of multi millet recipes. Consumer sensory evaluation is also a part of the product development process.

Small millet viz., kodo millet, little millet, foxtail millet and barnyard millet were selected for development of multi millets food products and standardized. The value added products including traditional recipes, bakery products, pasta products and instant food mixes. The products which are commonly prepared by using cereals were replaced with small millets and assessed its acceptability level among consumers.

### Traditional foods

Value added multi millet foods including breakfast recipes, sweet and snack recipes based on traditional methods were prepared and standardized. Breakfast recipes like *Idli, dosa, Idiyappam, Paniyaram, Puttu, Adai, flaked upma, venpongal and Chappathi*. Sweets like *sweet pongal, kolukkattai, Adhirasam, Kesari, and payasam*. Snack items like *Vadai, Pakoda, Ribbon pakoda, Omapodi, Murukku, Thatu vadai and seedai*. All the above recipes were developed with small millets (kodo millet, foxtail millet, little millet, barnyard millet and finger millet) replacing rice flour and other cereal grains. The products were standardized and evaluated for their sensory attributes by a panel of trained members using a nine point hedonic scale. The developed products were evaluated for their quality and nutritional attributes like moisture, energy, protein, fat, fibre, calcium and iron content using standard procedures.

### Bakery Products

Multi millets composite flour was prepared by using kodo millet, foxtail millet, little millet, barnyard millet and finger millet and it was incorporated in different variations from 10% to 50% level to standardize bread, bread roll, bun, dough nut, cake and cookies. The developed products were analyzed for their physical properties and nutrients using standard procedures. The sensory attributes like colour, flavor, texture and taste were evaluated by a panel of members using a nine point hedonic scale.

### Pasta Products

The extruded product of vermicelli was prepared from refined wheat flour and blending with multi millets composite flour in various proportions (10, 20, 30, 40 and 50%) and standardized the amount of acceptability.

## Instant Mixes

Traditional south Indian breakfast foods viz., *adai*, *puttu*, *payasam*, *halwa* mix, *murukku* mix, ribbon *pakoda* mix, *omapodi* mix, *vada* mix and health mix were selected. Instant mixes of these traditional products prepared from multi millet at different proportions of millets the proportion of rest of the ingredients in the instant mixes was maintained as the same as that of the traditional method of preparation.

Another set of ready to cook instant rice mixes viz., tomato rice, methi rice, bisbellabath, tamarind rice and biriyani were prepared using multi millets and evaluated its acceptability and nutrient content.

Multi Millets were substituted for cereal grains in the preparation of various traditional foods and standardized forty three products. The sensory evaluation result showed that the developed products were highly acceptable (Table 1). The developed products were found to be rich in protein, calcium and iron. The nutrient content of the multi millet products is presented in the Table 2.

Table: 4 Sensory evaluation of multi millet recipes

|                         | Name of the Product      | Colour and Appearance | Flavor   | Texture  | Taste    | Overall Acceptability |
|-------------------------|--------------------------|-----------------------|----------|----------|----------|-----------------------|
| <b>BREAK FAST FOODS</b> |                          |                       |          |          |          |                       |
| 1                       | <i>Idli</i>              | 8.4±0.32              | 8.4±0.21 | 8.5±0.20 | 8.4±0.14 | 8.5±0.14              |
| 2                       | <i>Dosa</i>              | 8.5±0.07              | 8.7±0.12 | 8.4±0.14 | 8.5±0.16 | 8.6±0.14              |
| 3                       | <i>Idiyappam</i>         | 8.2±0.25              | 8.2±0.11 | 8.3±0.11 | 8.5±0.06 | 8.5±0.16              |
| 4                       | <i>Paniyaram</i>         | 8.6±0.22              | 8.6±0.08 | 8.6±0.10 | 8.5±0.11 | 8.6±0.21              |
| 5                       | <i>Puttu</i>             | 8.2±0.12              | 8.3±0.10 | 8.4±0.21 | 8.4±0.12 | 8.4±0.46              |
| 6                       | <i>Adai</i>              | 8.8±0.33              | 8.8±0.34 | 8.6±0.13 | 8.6±0.14 | 8.7±0.23              |
| 7                       | <i>Chappathi</i>         | 8.8±0.41              | 8.7±0.18 | 8.7±0.18 | 8.6±0.16 | 8.8±0.25              |
| 8                       | <i>Venpongal</i>         | 8.8±0.21              | 8.8±0.15 | 8.8±0.14 | 8.8±0.18 | 8.8±0.20              |
| <b>SWEET PRODUCTS</b>   |                          |                       |          |          |          |                       |
| 9                       | <i>Sweet pongal</i>      | 8.8±0.41              | 8.6±0.05 | 8.7±0.12 | 8.8±0.06 | 8.8±0.02              |
| 10                      | <i>Halwa</i>             | 8.4±0.15              | 8.5±0.06 | 8.6±0.11 | 8.4±0.05 | 8.5±0.06              |
| 11                      | <i>Sweet Kolukkattai</i> | 8.2±0.10              | 8.2±0.10 | 8.4±0.14 | 8.5±0.04 | 8.4±0.04              |
| 12                      | <i>Payasam</i>           | 8.7±0.12              | 8.6±0.07 | 8.7±0.08 | 8.7±0.04 | 8.7±0.08              |
| 13                      | <i>Adhirasam</i>         | 8.3±0.19              | 8.4±0.09 | 8.4±0.14 | 8.5±0.02 | 8.6±0.04              |
| 14                      | <i>Kesari</i>            | 8.6±0.14              | 8.7±0.10 | 8.7±0.05 | 8.7±0.06 | 8.7±0.10              |
| <b>LUNCH</b>            |                          |                       |          |          |          |                       |
| 15                      | Tomato rice              | 8.4±0.12              | 8.3±0.14 | 8.4±0.14 | 8.4±0.14 | 8.5±0.12              |
| 16                      | Methi rice               | 8.4±0.11              | 8.2±0.15 | 8.6±0.09 | 8.3±0.12 | 8.4±0.14              |
| 17                      | <i>Bisibellabath</i>     | 8.5±0.07              | 8.4±0.16 | 8.5±0.10 | 8.4±0.15 | 8.6±0.16              |
| 18                      | Tamarind rice            | 8.5±0.08              | 8.6±0.16 | 8.6±0.12 | 8.3±0.11 | 8.5±0.12              |
| 19                      | <i>Biriyani</i>          | 8.3±0.10              | 8.3±0.14 | 8.4±0.10 | 8.4±0.10 | 8.6±0.14              |



| <b>SNACKS</b>                       |                      |          |          |          |           |          |
|-------------------------------------|----------------------|----------|----------|----------|-----------|----------|
| 20                                  | <i>Vadai</i>         | 8.2±0.04 | 8.3±0.16 | 8.4±0.23 | 8.5±0.014 | 8.4±0.12 |
| 21                                  | <i>Pakoda</i>        | 8.4±0.02 | 8.4±0.14 | 8.4±0.24 | 8.4±0.06  | 8.4±0.08 |
| 22                                  | <i>Ribbon pakoda</i> | 8.6±0.03 | 8.7±0.08 | 8.5±0.18 | 8.6±0.08  | 8.6±0.04 |
| 23                                  | <i>Omapodi</i>       | 8.4±0.04 | 8.3±0.10 | 8.4±0.14 | 8.4±0.10  | 8.3±0.32 |
| 24                                  | <i>Murukku</i>       | 8.5±0.08 | 8.4±0.24 | 8.4±0.09 | 8.5±0.12  | 8.5±0.26 |
| 25                                  | <i>Thatu vadai</i>   | 8.5±0.06 | 8.3±0.04 | 8.4±0.32 | 8.5±0.14  | 8.5±0.22 |
| 26                                  | <i>Seedai</i>        | 8.6±0.10 | 8.5±0.18 | 8.4±0.16 | 8.5±0.18  | 8.5±0.18 |
| <b>BAKERY</b>                       |                      |          |          |          |           |          |
| 27                                  | Bread                | 8.6±0.06 | 8.4±0.04 | 8.5±0.06 | 8.7±0.01  | 8.6±0.04 |
| 28                                  | Bread roll           | 8.5±0.08 | 8.4±0.02 | 8.4±0.08 | 8.5±0.01  | 8.5±0.14 |
| 29                                  | Bun                  | 8.4±0.06 | 8.4±0.06 | 8.4±0.04 | 8.4±0.03  | 8.5±0.12 |
| 30                                  | Cookies              | 8.7±0.02 | 8.8±0.08 | 8.6±0.12 | 8.7±0.02  | 8.8±0.14 |
| 31                                  | Cake                 | 8.4±0.04 | 8.3±0.04 | 8.4±0.16 | 8.5±0.05  | 8.5±0.16 |
| 32                                  | Doughnut             | 8.6±0.12 | 8.4±0.02 | 8.4±0.12 | 8.5±0.06  | 8.6±0.12 |
| <b>Extruded and flaked products</b> |                      |          |          |          |           |          |
| 33                                  | Flaked <i>upma</i>   | 8.4      | 8.3      | 8.4      | 8.6       | 8.5      |
| 34                                  | Vermicelli           | 8.2      | 8.2      | 8.3      | 8.3       | 8.3      |
| <b>Ready to cook mixes</b>          |                      |          |          |          |           |          |
| 35                                  | <i>Halwa mix</i>     | 8.5±0.17 | 8.4±0.16 | 8.6±0.10 | 8.4±0.50  | 8.6±0.16 |
| 36                                  | <i>Payasam mix</i>   | 8.7±0.10 | 8.6±0.12 | 8.7±0.04 | 8.7±0.02  | 8.7±0.14 |
| 37                                  | <i>Ribbon pakoda</i> | 8.5±0.30 | 8.7±0.18 | 8.5±0.28 | 8.6±0.18  | 8.6±0.22 |
| 38                                  | <i>Omapodi</i>       | 8.5±0.14 | 8.4±0.16 | 8.5±0.20 | 8.5±0.16  | 8.4±0.20 |
| 39                                  | <i>Murukku</i>       | 8.6±0.38 | 8.5±0.40 | 8.5±0.09 | 8.4±0.10  | 8.5±0.01 |
| 40                                  | <i>Vadai</i>         | 8.3±0.01 | 8.2±0.10 | 8.4±0.30 | 8.5±0.14  | 8.3±0.10 |
| 41                                  | <i>Vadagam</i>       | 8.6±0.06 | 8.3±0.12 | 8.3±0.13 | 8.4±0.32  | 8.4±0.18 |
| 42                                  | Health mix           | 8.7±0.02 | 8.6±0.01 | 8.7±0.10 | 8.6±0.16  | 8.8±0.10 |

Values are mean±SD

**Table: 5 Nutritive value of multi millet products (per 100g)**

| Sl. No.                 | Items            | Energy (K.cal) | Protein (g) | Fat (g) | Carbohydrate (g) | Fibre (g) | Calcium (mg) | Iron (mg) |
|-------------------------|------------------|----------------|-------------|---------|------------------|-----------|--------------|-----------|
| <b>BREAK FAST FOODS</b> |                  |                |             |         |                  |           |              |           |
| 1                       | <i>Idli</i>      | 273.32         | 12.86       | 2.88    | 63.07            | 3.64      | 55.51        | 4.28      |
| 2                       | <i>Dosa</i>      | 283.41         | 12.64       | 2.52    | 64.10            | 3.94      | 98.84        | 4.26      |
| 3                       | <i>Paniyaram</i> | 239.67         | 11.25       | 4.64    | 54.27            | 3.12      | 97.51        | 3.95      |
| 4                       | <i>Idiyappam</i> | 329.64         | 5.19        | 1.83    | 60.24            | 2.30      | 16.13        | 2.64      |
| 5                       | <i>Puttu</i>     | 322.49         | 6.00        | 1.08    | 61.36            | 3.28      | 68.28        | 3.45      |
| 6                       | <i>Adai</i>      | 301.99         | 13.68       | 2.37    | 62.64            | 4.97      | 128.32       | 4.22      |

|                                     |                          |        |       |       |       |      |        |      |
|-------------------------------------|--------------------------|--------|-------|-------|-------|------|--------|------|
| 7                                   | <i>Chappathi</i>         | 255.33 | 8.57  | 2.75  | 61.42 | 6.72 | 110.00 | 4.30 |
| 8                                   | <i>Venpongal</i>         | 309.94 | 14.86 | 7.32  | 55.81 | 4.65 | 100.08 | 4.76 |
| <b>LUNCH</b>                        |                          |        |       |       |       |      |        |      |
| 9                                   | Tomato rice              | 143.76 | 5.42  | 1.73  | 36.24 | 5.10 | 40.17  | 3.76 |
| 10                                  | <i>Methi rice</i>        | 218.94 | 7.80  | 4.95  | 48.43 | 6.29 | 37.77  | 3.62 |
| 11                                  | <i>Bisibellabath</i>     | 214.97 | 8.54  | 2.98  | 50.04 | 5.81 | 32.08  | 6.55 |
| 12                                  | Tamarind rice            | 229.76 | 7.15  | 2.78  | 52.59 | 5.83 | 40.30  | 4.46 |
| 13                                  | <i>Biryani rice</i>      | 193.86 | 7.66  | 2.29  | 47.17 | 6.67 | 55.28  | 7.28 |
| <b>SWEET PRODUCTS</b>               |                          |        |       |       |       |      |        |      |
| 14                                  | <i>Sweet pongal</i>      | 289.51 | 9.58  | 13.88 | 61.76 | 3.72 | 45.35  | 3.74 |
| 15                                  | <i>Sweet kolukkattai</i> | 324.84 | 7.50  | 6.39  | 64.30 | 2.13 | 142.58 | 4.01 |
| 16                                  | <i>Payasam</i>           | 264.91 | 5.04  | 4.06  | 59.72 | 3.56 | 50.35  | 3.25 |
| 17                                  | <i>Adhirasam</i>         | 356.30 | 4.41  | 10.01 | 86.93 | 2.33 | 67.64  | 2.79 |
| 18                                  | <i>Kesari</i>            | 373.65 | 4.14  | 13.64 | 63.16 | 2.40 | 75.99  | 3.04 |
| 19                                  | <i>Halwa</i>             | 377.34 | 4.35  | 6.37  | 64.51 | 2.73 | 48.63  | 1.89 |
| <b>SNACKS</b>                       |                          |        |       |       |       |      |        |      |
| 20                                  | <i>Vadai</i>             | 235.89 | 9.91  | 12.87 | 50.36 | 2.86 | 81.94  | 3.94 |
| 21                                  | <i>Pakoda</i>            | 218.16 | 7.28  | 12.60 | 52.98 | 6.62 | 120.39 | 3.90 |
| 22                                  | <i>Ribbon pakoda</i>     | 284.22 | 7.98  | 7.44  | 60.22 | 3.10 | 105.32 | 4.19 |
| 23                                  | <i>Murukku</i>           | 289.82 | 8.20  | 12.06 | 59.25 | 3.07 | 151.03 | 5.09 |
| 24                                  | <i>Omapodi</i>           | 370.03 | 8.06  | 7.45  | 66.56 | 3.55 | 78.44  | 3.89 |
| 25                                  | <i>Thatu vadai</i>       | 272.00 | 10.28 | 6.48  | 62.24 | 3.50 | 94.44  | 4.23 |
| 26                                  | <i>Seedai</i>            | 303.09 | 9.90  | 10.97 | 70.68 | 2.74 | 97.08  | 3.87 |
| <b>BAKERY</b>                       |                          |        |       |       |       |      |        |      |
| 27                                  | Bread                    | 310.45 | 10.54 | 2.91  | 88.52 | 1.76 | 48.76  | 3.47 |
| 28                                  | Bread Roll               | 348.76 | 12.47 | 1.28  | 72.37 | 1.76 | 35.16  | 3.02 |
| 29                                  | Bun                      | 329.79 | 11.01 | 1.24  | 82.01 | 1.76 | 56.56  | 3.06 |
| 30                                  | Cookies                  | 396.01 | 9.71  | 34.24 | 74.93 | 2.95 | 56.40  | 3.54 |
| 31                                  | Cake                     | 418.30 | 8.58  | 24.93 | 48.98 | 1.54 | 22.20  | 1.12 |
| 32                                  | Dough nut                | 361.60 | 13.78 | 1.41  | 68.68 | 2.38 | 43.90  | 2.21 |
| <b>Extruded and flaked products</b> |                          |        |       |       |       |      |        |      |
| 33                                  | Vermicelli               | 287.67 | 9.15  | 2.22  | 68.55 | 3.41 | 65.56  | 3.82 |
| 34                                  | Flaked <i>upma</i>       | 320.56 | 6.43  | 9.63  | 43.21 | 5.29 | 43.27  | 4.00 |
| <b>Ready to cook mixes</b>          |                          |        |       |       |       |      |        |      |
| 35                                  | <i>Halwa mix</i>         | 377.34 | 4.35  | 6.37  | 64.51 | 2.73 | 48.63  | 1.89 |
| 36                                  | <i>Payasam mix</i>       | 342.01 | 5.69  | 2.16  | 78.18 | 3.92 | 65.55  | 2.92 |
| 37                                  | <i>Murukku mix</i>       | 312.91 | 9.95  | 2.05  | 58.78 | 3.14 | 123.23 | 4.47 |
| 38                                  | <i>Ribbon pakoda Mix</i> | 309.91 | 9.45  | 3.05  | 58.78 | 3.14 | 143.23 | 4.43 |
| 39                                  | <i>Omapodi mix</i>       | 294.87 | 12.09 | 3.63  | 64.32 | 2.68 | 75.46  | 4.60 |
| 40                                  | <i>Vada mix</i>          | 275.01 | 11.56 | 3.40  | 58.87 | 2.28 | 94.93  | 4.32 |

|    |                   |        |       |      |       |      |        |      |
|----|-------------------|--------|-------|------|-------|------|--------|------|
| 41 | <i>Vadagam</i>    | 254.89 | 8.60  | 3.28 | 61.61 | 2.78 | 130.92 | 4.68 |
| 42 | <i>Health mix</i> | 382.90 | 12.91 | 5.52 | 81.08 | 6.36 | 127.49 | 5.19 |



**PANIYARAM**



**VENPONGAL**



**ADAI**

**Fig 2: Multi millet based food products- Breakfast foods**

Small millets viz., barnyard millet, kodo millet, foxtail millet and little millet are gaining popular in all type of consumers and people are also interested to use this type of food in their daily diet. Combination of all the small millet based recipes provide new taste, acceptability and also product varieties. These products help to satisfy the individual preference and choice. Further millet flour improves the nutrient content and also economically feasible which in turn improve the health status of the consumers.

## Bio availability and anti-diabetic studies of small millet based food products

### Bio availability of cookies

The bioavailability of nutrient content of cookies was evaluated by in vitro studies. For the study, rats were randomly divided into two groups. One group fed with multi millet cookies 500mg/ Kg of body weight and another group fed with 1000 mg /kg of body weight. Blood samples (0.3 ml) were drawn at 0, 1, 2, 4 and 8 hours post dose and collected in heparinized tubes. They were centrifuged at 2000 rpm for 5 minutes and plasma was collected and analysed the nutrients viz., carbohydrate, fat, protein, calcium, iron, thiamine and riboflavin by using standard procedure. The mean values of nutrient present in the plasma at different time intervals are presented in the Table. 4

**Table: 6 Mean values of nutrient content of cookies after administration in rats**

| Nutrients         | Treatments     | Time Intervals (hrs) |        |        |        |        |
|-------------------|----------------|----------------------|--------|--------|--------|--------|
|                   |                | 0                    | 1      | 2      | 4      | 8      |
| Carbohydrate (mg) | T <sub>1</sub> | 116.17               | 182.23 | 196.57 | 181.20 | 142.00 |
|                   | T <sub>2</sub> | 127.33               | 355.30 | 363.72 | 232.12 | 182.57 |
| Protein (mg)      | T <sub>1</sub> | 143.83               | 147.33 | 148.50 | 149.50 | 146.67 |
|                   | T <sub>2</sub> | 132.83               | 142.33 | 144.00 | 145.00 | 140.50 |
| Fat (mg)          | T <sub>1</sub> | 121.17               | 130.33 | 132.33 | 133.83 | 130.67 |
|                   | T <sub>2</sub> | 112.67               | 136.83 | 139.67 | 134.67 | 133.33 |
| Iron (µg)         | T <sub>1</sub> | 12.83                | 40.00  | 33.57  | 23.67  | 16.05  |
|                   | T <sub>2</sub> | 15.00                | 71.00  | 48.30  | 23.43  | 18.02  |
| Calcium (µg)      | T <sub>1</sub> | 4.17                 | 12.87  | 15.62  | 12.80  | 7.38   |
|                   | T <sub>2</sub> | 5.78                 | 14.77  | 18.02  | 14.83  | 10.47  |
| Riboflavin (µg)   | T <sub>1</sub> | 7.85                 | 14.22  | 18.47  | 16.08  | 11.57  |
|                   | T <sub>2</sub> | 7.63                 | 17.75  | 22.27  | 17.72  | 14.70  |
| Thiamine (µg)     | T <sub>1</sub> | 10.87                | 18.72  | 21.10  | 16.57  | 14.13  |
|                   | T <sub>2</sub> | 11.78                | 18.05  | 21.18  | 20.18  | 17.93  |

T<sub>1</sub> – 500 mg of cookies per Kg of body weight, T<sub>2</sub> – 1000 mg of cookies per Kg of body weight

The results showed that the bioavailability of nutrient absorption was found to be maximum and the availability of carbohydrate and protein were maximum at 2 hours and fat at 4 hours and remaining minerals and vitamins were found maximum at 4 hours interval in the rats



**Fig 3: Bioavailability studies in rats**

### Bio availability of instant food mixes

#### SET-1

The bioavailability of instant mixes namely multi millet *adai* mix, multi millet *kitchadi* mix, multi millet drumstick leaves *dosa* mix, multi millet palak leaves *dosa* mix and multi millet fenugreek leaves rice mix were evaluated in the Wistar rats at 0, 1, 2, 4 and 8 hours of post dose period. The blood sample was collected from the rats and analysed the nutrients viz., carbohydrate, fat, protein, calcium, iron, thiamine and riboflavin by using standard procedure and the results are presented in the Table. 5

The results showed that the peak concentration of carbohydrate and protein were higher after 2 hours of administration while the fat was found to be 4 hours of post dose period. The vitamins (thiamine and riboflavin) and minerals (calcium and iron) concentration were higher in the blood after 2 hours of administration of instant mixes.

**Table: 7 Mean values of nutrient concentration in blood plasma of rats**

| Nutrients         | Treatments     | Time Intervals (hrs) |        |        |        |        |
|-------------------|----------------|----------------------|--------|--------|--------|--------|
|                   |                | 0                    | 1      | 2      | 4      | 8      |
| Carbohydrate (mg) | T <sub>1</sub> | 118.12               | 162.42 | 187.63 | 170.02 | 139.12 |
|                   | T <sub>2</sub> | 136.23               | 354.16 | 373.31 | 248.54 | 193.17 |
|                   | T <sub>3</sub> | 112.35               | 286.26 | 314.21 | 271.26 | 187.65 |
|                   | T <sub>4</sub> | 117.26               | 277.34 | 324.28 | 234.92 | 181.20 |
|                   | T <sub>5</sub> | 119.32               | 289.62 | 384.24 | 268.61 | 188.32 |
| Protein (mg)      | T <sub>1</sub> | 134.30               | 137.13 | 138.40 | 139.45 | 136.27 |
|                   | T <sub>2</sub> | 122.13               | 132.63 | 134.12 | 135.30 | 130.10 |
|                   | T <sub>3</sub> | 136.18               | 139.26 | 142.21 | 140.19 | 138.24 |
|                   | T <sub>4</sub> | 132.10               | 138.34 | 141.20 | 139.28 | 138.42 |
|                   | T <sub>5</sub> | 134.21               | 136.26 | 139.51 | 138.24 | 135.28 |
| Fat (mg)          | T <sub>1</sub> | 131.27               | 136.53 | 139.23 | 133.11 | 130.67 |
|                   | T <sub>2</sub> | 115.27               | 137.13 | 140.57 | 136.20 | 132.53 |

|                 |                |        |        |        |        |        |
|-----------------|----------------|--------|--------|--------|--------|--------|
|                 | T <sub>3</sub> | 117.20 | 119.35 | 125.30 | 122.41 | 121.20 |
|                 | T <sub>4</sub> | 122.56 | 128.24 | 131.04 | 130.25 | 130.02 |
|                 | T <sub>5</sub> | 130.75 | 132.20 | 134.52 | 132.50 | 130.10 |
| Iron (µg)       | T <sub>1</sub> | 12.41  | 41.00  | 34.56  | 24.17  | 17.55  |
|                 | T <sub>2</sub> | 17.50  | 77.00  | 49.30  | 26.43  | 19.82  |
|                 | T <sub>3</sub> | 11.12  | 36.21  | 32.14  | 28.40  | 22.16  |
|                 | T <sub>4</sub> | 13.52  | 43.26  | 46.51  | 27.50  | 18.24  |
|                 | T <sub>5</sub> | 17.50  | 34.50  | 36.81  | 32.16  | 24.30  |
| Calcium (µg)    | T <sub>1</sub> | 4.17   | 12.87  | 15.26  | 13.80  | 7.08   |
|                 | T <sub>2</sub> | 5.80   | 14.70  | 18.42  | 14.13  | 12.41  |
|                 | T <sub>3</sub> | 6.12   | 11.14  | 19.20  | 11.24  | 6.19   |
|                 | T <sub>4</sub> | 7.15   | 13.51  | 18.53  | 12.80  | 6.80   |
|                 | T <sub>5</sub> | 5.45   | 16.50  | 17.58  | 11.30  | 7.91   |
| Riboflavin (µg) | T <sub>1</sub> | 7.82   | 15.32  | 17.40  | 16.20  | 12.50  |
|                 | T <sub>2</sub> | 7.63   | 17.75  | 22.47  | 17.52  | 10.70  |
|                 | T <sub>3</sub> | 7.31   | 17.62  | 22.30  | 16.52  | 12.34  |
|                 | T <sub>4</sub> | 7.26   | 17.95  | 22.51  | 16.24  | 12.52  |
|                 | T <sub>5</sub> | 7.51   | 17.82  | 22.45  | 16.30  | 12.30  |
| Thiamine (µg)   | T <sub>1</sub> | 12.86  | 15.70  | 22.10  | 17.54  | 12.13  |
|                 | T <sub>2</sub> | 11.48  | 16.25  | 21.19  | 21.08  | 18.23  |
|                 | T <sub>3</sub> | 10.26  | 16.23  | 20.31  | 19.26  | 17.23  |
|                 | T <sub>4</sub> | 10.81  | 16.50  | 21.25  | 19.23  | 17.50  |
|                 | T <sub>5</sub> | 10.32  | 16.32  | 21.92  | 19.82  | 18.56  |

|                |   |
|----------------|---|
| T <sub>1</sub> | Multi millet <i>adai</i> mix                  |
| T <sub>2</sub> | Multi millet <i>kitchadi</i> mix              |
| T <sub>3</sub> | Multi millet drumstick leaves <i>dosa</i> mix |
| T <sub>4</sub> | Multi millet palak leaves <i>dosa</i> mix     |
| T <sub>5</sub> | Multi millet fenugreek leaves rice mix        |

## SET-II

The bioavailability of instant mixes namely Multi millet drumstick leaves *chappathi* mix, Multi millet vegetable *rotti* mix, Multi millet palak leaves rice mix, Multi millet *upma* mix, Multi millet *idiyappam* mix were evaluated in the Wistar rats at 0, 1, 2, 4, 8, 12 and 24 hours of post dose period. The blood sample was collected from the rats and analysed nutrients viz., carbohydrate, fat, protein, calcium, iron, thiamine and riboflavin by using standard procedure and the results are presented in the Table. 6

**Table: 8 Mean values of nutrient concentration in blood plasma of rats**

| Nutrients            | Treatments     | Time Intervals (hrs) |        |         |        |        |        |        |
|----------------------|----------------|----------------------|--------|---------|--------|--------|--------|--------|
|                      |                | 0                    | 1      | 2       | 4      | 8      | 12     | 24     |
| Carbohydrate (mg/dl) | T <sub>0</sub> | 136.33               | 139.00 | 154.33  | 157.50 | 153.50 | 145.67 | 140.33 |
|                      | T <sub>1</sub> | 136.33               | 548.67 | 194.17  | 179.00 | 170.83 | 148.83 | 143.00 |
|                      | T <sub>2</sub> | 102.33               | 216.50 | 284.17  | 267.17 | 239.67 | 218.50 | 214.83 |
|                      | T <sub>3</sub> | 126.67               | 139.33 | 196.50  | 184.33 | 169.83 | 155.00 | 135.50 |
|                      | T <sub>4</sub> | 164.50               | 149.67 | 224.83  | 182.17 | 173.83 | 168.67 | 164.50 |
|                      | T <sub>5</sub> | 110.33               | 164.17 | 172.67  | 171.50 | 133.67 | 123.83 | 108.67 |
| Protein (mg/dl)      | T <sub>0</sub> | 10.13                | 10.35  | 10.45   | 10.58  | 10.47  | 10.43  | 10.28  |
|                      | T <sub>1</sub> | 10.43                | 18.92  | 19.28   | 16.37  | 15.23  | 14.07  | 13.10  |
|                      | T <sub>2</sub> | 9.72                 | 24.57  | 13.03   | 12.70  | 11.38  | 10.23  | 9.98   |
|                      | T <sub>3</sub> | 12.72                | 16.73  | 16.88   | 17.25  | 15.63  | 13.47  | 13.25  |
|                      | T <sub>4</sub> | 9.10                 | 23.58  | 23.83   | 20.58  | 18.48  | 16.40  | 10.60  |
|                      | T <sub>5</sub> | 6.20                 | 48.73  | 28.20   | 18.55  | 17.20  | 14.30  | 13.40  |
| Fat (mg/dl)          | T <sub>0</sub> | 445.95               | 446.28 | 445.90  | 446.65 | 446.40 | 446.32 | 446.22 |
|                      | T <sub>1</sub> | 445.05               | 687.38 | 1077.83 | 767.67 | 755.82 | 745.60 | 735.67 |
|                      | T <sub>2</sub> | 452.62               | 572.52 | 863.95  | 672.50 | 664.80 | 555.95 | 436.05 |
|                      | T <sub>3</sub> | 445.05               | 452.03 | 637.00  | 580.57 | 578.83 | 369.40 | 367.83 |
|                      | T <sub>4</sub> | 490.47               | 495.42 | 568.27  | 808.95 | 658.25 | 568.92 | 520.57 |
|                      | T <sub>5</sub> | 404.50               | 412.05 | 510.75  | 824.13 | 812.47 | 583.10 | 458.00 |
| Iron (µg/dl)         | T <sub>0</sub> | 22.85                | 21.60  | 22.15   | 22.22  | 22.25  | 22.30  | 22.13  |
|                      | T <sub>1</sub> | 22.87                | 77.62  | 83.10   | 81.92  | 72.32  | 57.37  | 37.43  |
|                      | T <sub>2</sub> | 27.85                | 67.62  | 39.00   | 37.05  | 31.68  | 27.23  | 23.38  |
|                      | T <sub>3</sub> | 28.10                | 80.30  | 74.25   | 65.97  | 46.37  | 22.58  | 16.17  |
|                      | T <sub>4</sub> | 27.02                | 77.93  | 75.43   | 42.75  | 27.87  | 27.25  | 26.77  |
|                      | T <sub>5</sub> | 28.35                | 70.05  | 58.37   | 42.45  | 31.83  | 29.43  | 28.90  |
| Calcium (mg/dl)      | T <sub>0</sub> | 3.47                 | 3.62   | 3.70    | 3.67   | 3.68   | 3.57   | 3.48   |
|                      | T <sub>1</sub> | 3.47                 | 8.12   | 11.03   | 9.38   | 7.60   | 6.58   | 4.43   |
|                      | T <sub>2</sub> | 2.80                 | 9.73   | 20.68   | 20.67  | 9.20   | 4.27   | 3.25   |
|                      | T <sub>3</sub> | 4.33                 | 5.80   | 17.65   | 7.38   | 5.47   | 5.03   | 4.53   |
|                      | T <sub>4</sub> | 2.82                 | 14.73  | 16.20   | 25.18  | 9.53   | 3.38   | 3.02   |
|                      | T <sub>5</sub> | 2.13                 | 2.47   | 2.52    | 9.28   | 14.37  | 13.43  | 9.40   |
| Riboflavin (µg/dl)   | T <sub>0</sub> | 2.56                 | 2.50   | 2.84    | 2.79   | 2.78   | 2.77   | 2.67   |
|                      | T <sub>1</sub> | 2.56                 | 19.57  | 15.65   | 9.34   | 5.23   | 4.56   | 3.43   |
|                      | T <sub>2</sub> | 2.50                 | 21.74  | 13.50   | 12.44  | 11.24  | 9.70   | 7.46   |
|                      | T <sub>3</sub> | 2.84                 | 23.73  | 20.32   | 13.99  | 8.64   | 8.23   | 6.55   |

|                  |                |      |       |       |       |       |       |       |
|------------------|----------------|------|-------|-------|-------|-------|-------|-------|
|                  | T <sub>4</sub> | 2.79 | 24.53 | 8.84  | 8.49  | 6.27  | 5.41  | 3.98  |
|                  | T <sub>5</sub> | 2.78 | 23.16 | 15.54 | 8.21  | 6.03  | 4.44  | 3.45  |
| Thiamine (µg/dl) | T <sub>0</sub> | 4.93 | 5.02  | 5.03  | 5.10  | 5.00  | 4.95  | 4.95  |
|                  | T <sub>1</sub> | 4.93 | 17.55 | 21.20 | 21.85 | 15.82 | 11.98 | 8.30  |
|                  | T <sub>2</sub> | 4.13 | 27.63 | 18.95 | 16.72 | 16.72 | 13.48 | 7.25  |
|                  | T <sub>3</sub> | 4.02 | 27.28 | 23.50 | 20.40 | 16.48 | 12.88 | 9.18  |
|                  | T <sub>4</sub> | 4.25 | 24.53 | 20.63 | 17.67 | 15.12 | 10.05 | 7.90  |
|                  | T <sub>5</sub> | 4.22 | 29.60 | 26.58 | 21.15 | 20.00 | 18.83 | 14.73 |

|                |  |
|----------------|--|
| T <sub>0</sub> | Control  |
| T <sub>1</sub> | Multi millet drumstick leaves <i>chappathi</i> mix |
| T <sub>2</sub> | Multi millet vegetable <i>rotti</i> mix            |
| T <sub>3</sub> | Multi millet palak leaves rice mix                 |
| T <sub>4</sub> | Multi millet <i>upma</i> mix                       |
| T <sub>5</sub> | Multi millet <i>idiyappam</i> mix                  |

The results showed that the peak concentration of carbohydrate and protein were higher at after 2 hours of administration while the fat was found at 4 hours of post dose period. The remaining vitamins (thiamine and riboflavin) and minerals (calcium and iron) concentration were higher after 2 hours of administration of instant mixes.

#### **Anti-diabetic activity studies of multi millet instant food mixes**

Anti-diabetic activity study of millet products was conducted in Wistar albino rats. The rats weighted around 200-300g were taken and placed at random and allocated to treatment groups in Polypropylene cages and paddy husk as bedding. Animal care procedure and experimental protocol were approved by the institutional Animal Ethics Committee (IAEC), Karpagam University and Coimbatore, India. From the first day of the study, the animals' temperature  $24 \pm 2^\circ\text{C}$  and relative humidity of 30-70% following 12:12 light: dark cycle. All the animals provided with free access to water and standard pellet laboratory animal diet

#### **Anti-diabetic activities of multi millet instant food mixes**

The Anti-diabetic activities of multi millet instant food mixes (multi millet drumstick leaves *chappathi* mix, multi millet vegetable *rotti* mix, multi millet palak leaves rice mix, multi millet upma mix and multi millet *idiyappam* mix) were evaluated in rats.

The Wistar albino rats (66 rats) were housed in large spacious cages and they were divided into eleven groups (6 rats per group). The animals were acclimatized to the standard environmental condition of temperature ( $22^\circ\text{C} \pm 5^\circ\text{C}$ ) and humidity ( $55 \pm 5\%$ ) and 12hrs light and dark cycles throughout the experimental period.



The first group marked as T<sub>0</sub> which was served as normal control, then the second group marked as T<sub>1</sub> and the diabetes mellitus was induced in this group of rats by single intraperitoneal injection of freshly prepared solution of Glibenclamide (600µg/kg) in physiological saline after overnight fasting for 12hrs. Glibenclamide is commonly used to produce diabetes mellitus in experimental animals due to its ability to destroy the β-cells of pancreas possibly by generating the excess reactive oxygen species such as H<sub>2</sub>O<sub>2</sub>, O<sub>2</sub> and HO. The development of hyper glycaemia in rats was confirmed by plasma glucose estimation on 72hrs post glibenclamide injection. The rats with fasting plasma glucose level of >150mg/dl were used for this experiment.

The experiment groups T<sub>2</sub>- T<sub>11</sub> were fed with multi millet instant food mixes and the details of mixes as given below

#### Grouping of animals for anti-diabetic study

| Sl. No.         | Treatments   |
|-----------------|--|
| T <sub>0</sub>  | Control  |
| T <sub>1</sub>  | Diabetic control                                   |
| T <sub>2</sub>  | Multi millet drumstick leaves <i>chappathi</i> mix |
| T <sub>3</sub>  | Multi millet vegetable <i>rotti</i> mix            |
| T <sub>4</sub>  | Multi millet palak leaves rice mix                 |
| T <sub>5</sub>  | Multi millet <i>upma</i> mix                       |
| T <sub>6</sub>  | Multi millet <i>idiyappam</i> mix                  |
| T <sub>7</sub>  | Multi millet <i>adai</i> mix                       |
| T <sub>8</sub>  | Multi millet drumstick leaves <i>dosa</i> mix      |
| T <sub>9</sub>  | Multi millet <i>kitchadi</i> mix                   |
| T <sub>10</sub> | Multi millet palak leaves <i>dosa</i> mix          |
| T <sub>11</sub> | Multi millet fenugreek leaves rice mix             |

The group fed with multi millet instant mixes 1000mg/ Kg of body weight and blood samples (0.3 ml) were drawn at 0, 1, 3, 7 and 15 hours post dose and collected in heparinized tubes. They were centrifuged at 2000 rpm for 5 minutes and plasma was collected and analysed the blood glucose concentration by using standard procedure. The mean values of glucose present in the plasma at different time intervals are presented in the Table. 7

**Table: 9 Mean glucose concentration present in the plasma of rats (mg/dl)**

| Sl. No.         | Treatments   | Time intervals |        |        |        |        |
|-----------------|--|----------------|--------|--------|--------|--------|
|                 |  | 0              | 1      | 3      | 7      | 15     |
| T <sub>0</sub>  | Control  | 113.67         | 302.67 | 293.67 | 281.83 | 176.83 |
| T <sub>1</sub>  | Diabetic control                                   | 113.67         | 313.00 | 242.50 | 234.67 | 232.83 |
| T <sub>2</sub>  | Multi millet drumstick leaves <i>chappathi</i> mix | 152.50         | 316.00 | 294.17 | 193.50 | 140.00 |
| T <sub>3</sub>  | Multi millet vegetable <i>rotti</i> mix            | 129.67         | 344.50 | 263.33 | 237.00 | 176.33 |
| T <sub>4</sub>  | Multi millet palak leaves rice mix                 | 100.00         | 304.67 | 285.17 | 248.17 | 193.50 |
| T <sub>5</sub>  | Multi millet <i>upma</i> mix                       | 121.17         | 304.17 | 224.50 | 179.00 | 166.83 |
| T <sub>6</sub>  | Multi millet <i>idiyappam</i> mix                  | 113.17         | 313.50 | 266.50 | 240.17 | 239.17 |
| T <sub>7</sub>  | Multi millet <i>adai</i> mix                       | 110.83         | 316.17 | 243.50 | 163.50 | 166.83 |
| T <sub>8</sub>  | Multi millet drumstick leaves <i>dosa</i> mix      | 144.83         | 352.83 | 252.83 | 178.17 | 173.83 |
| T <sub>9</sub>  | Multi millet <i>kitchadi</i> mix                   | 100.00         | 304.67 | 253.50 | 186.00 | 179.00 |
| T <sub>10</sub> | Multi millet palak leaves <i>dosa</i> mix          | 121.17         | 304.17 | 244.50 | 179.17 | 176.83 |
| T <sub>11</sub> | Multi millet fenugreek leaves rice mix             | 113.17         | 313.50 | 266.50 | 160.17 | 152.50 |

The results showed that significant reduction in the blood glucose level after sever hours of post feeding of multi millet based instant mixes compared to normal and diabetic rats. Among the products multi millet drumstick leaves *chappathi* mix showed the maximum reduction in blood glucose. Among the products multi millet fenugreek leaves rice mix showed the maximum reduction in blood glucose followed by multi millet *adai* mix, multi millet drumstick leaves *dosa* mix, multi millet *upma* mix, multi millet palak leaves *dosa* mix, multi millet *kitchadi* mix.

**Table: 10 Glycemic Index (GI) of small millet flours**

| Flour                | GI value |
|----------------------|----------|
| Refined wheat flour  | 71.33    |
| Kodo millet flour    | 43.91    |
| Little millet flour  | 41.42    |
| Foxtail millet flour | 41.04    |

The kodo millet flour, little millet flour and foxtail millet flour had low glycemic index ranging (41.04-43.91) when compared to that of refined wheat flour (71.33), the therapeutic products prepared with multi millet showed a significant reduction in blood glucose level which indicates the anti-diabetic activity in the experimental rats.