Dietary management of finger millet (*Eleusine coracana* L. Gaerth) controls diabetes

Millets are small grained, annual, warm weather cereals that includes 8000 species within 600 genera, of which only 35 species comprising 20 genera have been domesticated. Finger millet is grown as an important food crop in many developing countries of the tropical region; mainly in Africa and Asia. It is known as *ragi* and *mandia* in Bastar region of Chhattisgarh. Millets offer both nutritional and livelihood security for human being and fodder security for diverse livestock population in dryland regions of rural India. There is a surge in demand for millets for both food and non-food uses[1].

Finger millet contains more fibre, minerals and vitamins, which are normally deficient in the Indian diet, and has eight times more calcium than other cereals. This can be stored for many years under normal room temperature. India is the largest producer of millet grains, producing about 33–37% of a total of 28 million tonnes of the world produce. Finger millet is converted to flour for preparation of various food items. It can be exploited for its nutritional benefits and value added nutritive health foods. The high calcium, high soluble fibre, low fat and low glycemic index of malted grains is effective in controlling the blood glucose levels of diabetics[2,3].

Studies were conducted on diabetics (male and female) living in different rural and urban locations from December 2007 to January 2008. We selected 13 diabetics and asked them to replace their regular wheat chapati with multigrain chapati (ragi and wheat in 30 : 70 ratio). Observations were recorded before starting multigrain chapati diet by using Accu-check glucometer which works on random blood sugar (RBS) basis under supervision of doctor to avoid any casualty.

One advantage of selecting diabetics was that they preferred wheat to rice to maintain their sugar levels.

The sample size was small in number ($n \leq 30$) and the distribution of the variate was not normal too. Therefore, *t*-test statistics was applied to analyse the observation including mean, mean deviation, and standard deviation for analysis. Initial five observations were compared with further observations of blood glucose and then the values deviated with the mean. The deviated values were squared for calculation of standard deviation. The lowest values of each samples arranged which were calculated the *t*-test statistics using the formulae

$$t = [X - \mu]/s/\sqrt{n},$$

where X is the sample mean, μ the population mean (lowest value) and s the standard deviation.

$$S = \sqrt{1/(n-1)\Sigma(X-x)^2},$$

where x is the variable and X the mean of sample.

Three distinct groups with different glucose levels were found, viz. high (more than 400 mg/dl), moderate (200–400 mg/dl) and low (less than 200 mg/dl). The sugar level in high glucose persons (Table 1) was lowered by continuous consumption of multigrain flour. All persons who consumed the multigrain chapati were found to have considerably decreased blood glucose levels. Two samples (2 and 10) either stopped diabetes medicines or reduced up to 50% of the prescribed dosage (Table 1).

The moderate glucose level group showed decreasing trend up to 98% during the treatment. Table 1 shows more people who did not consume multigrain chapati during the initial five observations and when they start consuming it, they had reduced levels of glucose in blood. High glucose levels (samples 1, 3, 4, 5, 8, 9, 10 and 12) were brought under control after multigrain chapati replaced wheat chapati. Moderate level blood sugar samples showed (samples 2, 6 and 7) drastic lowering of glucose values; whereas the lower group showed reduction in the glucose level (samples 11 and 12) also. Mean deviation (Table 2) was

Table 1. Blood glucose values before and after observations (mg/dl)

Treatment (sample)	Mean values (before observation)	Observations of samples at one-day interval (mg/dl) 1	2	3	4	5	6	7	8	9	10	11	Total	Average
1	423	438	432	362	313	356	288	324	323	371	285	281	3773	343.00
2	207	204	137	113	171	136	116	124	113	94	92	98	1398	127.09
3	591	591	592	593	426	517	490	454	401	384	401	398	5247	477.00
4	411	363	326	324	301	243	257	243	297	271	243	234	3102	282.00
5	441	315	243	192	195	210	241	258	255	164	168	164	2405	218.64
6	288	330	252	272	228	199	205	200	218	178	152	169	2403	218.45
7	368	420	342	412	297	290	325	282	241	251	242	206	3308	300.73
8	509	404	420	327	361	367	285	179	173	149	163	153	2981	271.00
9	461	416	436	392	360	556	299	299	330	298	258	189	3833	348.45
10	468	339	290	307	277	268	222	174	203	220	210	184	2694	244.91
11	184	182	167	170	157	153	90	87	84	86	89	91	1356	123.27
12	430	436	289	248	310	286	257	235	245	232	193	201	2932	266.55
13	129	129	130	116	123	116	84	94	84	101	103	102	1182	107.45
Total days	4910	4567	4056	3828	3519	3697	3159	2953	2967	2799	2599	2470		
Average	360	331	289	294	271	267	243	227	228	215	200	190		

Table 2. Mean deviation of blood glucose values from original values

Treatment (sample)	Observations of samples at one-day interval										
	1	2	3	4	5	6	7	8	9	10	11
1	95.0	337.0	25.0	288.0	68.0	220.0	104.0	219.0	152.0	133.0	148.0
2	76.9	9.9	–14.1	43.9	8.9	–11.1	–3.1	–14.1	–33.1	–35.1	–29.1
3	114.0	115.0	116.0	–51.0	40.0	13.0	–23.0	–76.0	–93.0	–76.0	–79.0
4	81.0	44.0	42.0	19.0	–39.0	–25.0	–39.0	15.0	–11.0	–39.0	–48.0
5	96.4	24.4	–26.6	–23.6	–8.6	22.4	39.4	36.4	–54.6	–50.6	–54.6
6	111.5	33.5	53.5	9.5	–19.5	–13.5	–18.5	–0.5	–40.5	–66.5	–49.5
7	119.3	41.3	111.3	–3.7	–10.7	24.3	–18.7	–59.7	–49.7	–58.7	–94.7
8	133.0	149.0	56.0	90.0	96.0	14.0	–92.0	–98.0	–122.0	–108.0	–118.0
9	67.5	87.5	43.5	11.5	207.5	–49.5	–49.5	–18.5	–50.5	–90.5	–159.5
10	94.1	45.1	62.1	32.1	23.1	–22.9	–70.9	–41.9	–24.9	–34.9	–60.9
11	58.7	43.7	46.7	33.7	29.7	–33.3	–36.3	–39.3	–37.3	–34.3	–32.3
12	169.5	22.5	–18.5	43.5	19.5	–9.5	–31.5	–21.5	–34.5	–73.5	–65.5
13	21.5	22.5	8.5	15.5	8.5	–23.5	–13.5	–23.5	–6.5	–4.5	–5.5

Table 3. Standard deviation of blood glucose values

Treatment (sample)	Observations of samples at one-day interval										
	1	2	3	4	5	6	7	8	9	10	11
1	752.08	9464.08	52.08	6912.00	385.33	4033.33	901.33	3996.75	1925.33	1474.08	1825.33
2	492.92	8.18	16.55	160.67	6.61	10.25	0.80	16.55	91.25	102.61	70.52
3	1083.00	1102.08	1121.33	216.75	133.33	14.08	44.08	481.33	720.75	481.33	520.08
4	546.75	161.33	147.00	30.08	126.75	52.08	126.75	18.75	10.08	126.75	192.00
5	773.83	49.47	59.12	46.56	6.22	41.68	129.12	110.19	248.76	213.67	248.76
6	1036.87	93.77	238.93	7.59	31.54	15.09	28.38	0.02	136.38	368.02	203.81
7	1185.50	141.95	1031.80	1.16	9.59	49.10	29.23	297.28	206.07	287.41	747.77
8	1474.08	1850.08	261.33	675.00	768.00	16.33	705.33	800.33	1240.33	972.00	1160.33
9	380.20	638.68	158.02	11.11	3589.59	203.81	203.81	28.38	212.14	681.84	2118.81
10	737.76	169.43	321.27	85.82	44.43	43.74	419.01	146.36	51.71	101.55	309.16
11	287.41	159.34	181.95	94.79	73.64	92.26	109.64	128.53	115.77	97.88	86.79
12	2392.90	42.02	28.66	157.36	31.54	7.59	82.93	38.68	99.45	450.74	358.02
13	38.68	42.36	6.09	20.14	6.09	45.84	15.09	45.84	3.47	1.65	2.48

Table 4. *t*-test for blood glucose values

t-test (sample)	Lowest level	Observations of samples at one-day interval										
		1	2	3	4	5	6	7	8	9	10	11
1	281	0.17	–0.15	0.60	–0.24	0.03	–0.26	–0.16	–0.22	–0.11	–0.26	–0.27
2	92	0.12	–0.41	–1.55	–0.64	–1.44	–2.00	–8.89	–1.80	–0.85	–0.95	–1.16
3	384	0.22	–0.63	–0.62	–1.40	–2.90	–7.05	–4.30	–1.43	–1.32	–1.67	–1.55
4	234	0.16	–0.93	–1.21	–2.69	–1.47	–2.91	–1.77	–4.85	–5.31	–1.67	–1.52
5	164	0.15	–0.74	–1.40	–2.15	–5.79	–2.06	–0.96	–0.91	–0.62	–1.15	–1.05
6	169	0.12	–0.46	–0.67	–3.22	–2.18	–3.73	–2.63	–109.89	–1.12	–0.84	–1.27
7	206	0.21	–0.56	–0.39	–6.77	–5.21	–2.38	–2.59	–1.00	–1.42	–1.16	–0.74
8	149	0.24	–0.03	0.00	–0.28	–0.16	–1.01	–0.39	–0.66	–0.54	–0.67	–0.58
9	189	0.63	–0.37	–0.62	–3.36	–0.23	0.10	–1.28	–3.44	–1.10	–0.71	–0.47
10	174	0.20	–0.47	–0.55	–0.93	–1.64	–1.76	–0.74	–1.56	–2.31	–1.52	–0.91
11	84	0.18	–0.15	–0.23	–0.29	–0.45	–0.43	–0.86	–0.82	–0.88	–0.94	–0.98
12	193	0.12	–0.28	–2.45	–1.30	–2.05	–4.84	–1.71	–2.78	–1.65	–0.82	–1.08
13	84	0.29	–0.74	–1.92	–1.29	–2.13	–0.86	–2.13	–1.11	–4.44	–5.41	–4.32
t at 5%						2.18						

applied to blood glucose level of samples to find out the variation. The negative values showed glucose level lower than mean while positive value showed glucose level higher than mean. Table 2 shows the decrease in glucose content, and no remarkable decrease was seen in the samples. Table 3 shows standard deviation of blood glucose, where each sample largely deviates from initial to final observation. The glucose level has responded to treated diet ranging from 1.16 to 9464.08 points.

Testing of data was not significant at 5% level but reversing the site of analysis was negative which is important because it indicated progressively lower values than the initial values. The lowest value of total observations was considered as mean to check each interval of observation (Table 4).

The study involved different experiences of people taking medicine and multigrain flour. The multigrain flour on consumption energized and maintained the glucose level, whereas medicines did not give such feeling because the blood sugar level went down and required energy could not be obtained from it; medicine has not provided any nutrition.

The higher level of fibre present in finger millet made the chapati tasty and binding capacity of wheat made chapati consist form. Although the colour of multigrain chapati was darker than wheat chapati, it was a healthier option. The proportion of finger millet grain could be varied according to age of persons. More finger millet proportion made the chapati hard. People of all age groups participated enthusiastically in this study[5,6].

Health is an important issue for all of us. Diabetes can be managed by slight modification in diet and low dosage of medicine.

1. Desikachar, H. S. R., *Curr. Sci*., 1982, **16**, 284.
2. Pradhan, A., Nag, S. K., Tommar, N. S. and Sharma, R. L., *J. Rural Dev. – Kurukshetra*, 2008, **56**, 47–48.
3. Seetharam, N. and Rao, D. B., *The Hindu Survey of Indian Agriculture*, 2007, pp. 36–38.
4. Umapathy, K. P. and Kulsum, A., *J. Mysore Univ*., 1976, **37**, 45–48.
5. Venkatanarayan, S., Sreenivasa Murthy, V. and Satyanarayan Rao, B. A., *J. Food. Sci. Technol*., 1979, **16**, 204–206.
6. Wilkies, H. G., *Wallerstein Lab. Commun*., 1969, **32**, 93–100.

ACKNOWLEDGEMENT. We thank the National Agricultural Innovative Project Fund, World Bank, for financial support.

Received 6 November 2008; revised accepted 19 February 2010

ADIKANT PRADHAN*
S. K. NAG
S. K. PATIL

S.G. College of Agriculture and Research Station,
Jagdalpur 494 005, India
**For correspondence.*
e-mail: adi_197753@rediffmail.com

Laser ablation of semiconductor thin films – dependence of deposition rate on bandgap

The availability of high power pulsed and continuous wave (CW) lasers has made laser materials processing (LMP) industrially important. In semiconductor technology, lasers are being used for wafer marking, ohmic contact formation, ion implantation annealing and thin film deposition[1]. Due to the extremely fast nature of laser heating, direct conversion from solid to vapour phase may occur instead of melting, which is the process of ablation. A number of different types of semiconductor films have been deposited by laser ablation but a direct comparison between these is absent in the literature. This report compares the dependence of the deposition rate of thin films of wide-band gap such as BN and narrow gap semiconductors such as GaSb by ruby laser ablation.

Considerable work has been done in India since the 1980s on the deposition of a range of semiconductors in the Materials Science Centre at IIT Kharagpur[2–7]. Laser ablation was carried out using a pulsed ruby laser $\lambda = 694$ nm (1.786 eV) in a system consisting of a cylindrical stainless steel chamber provided with quartz windows. The chamber was pumped down to 10^{-6} mmHg using rotary and diffusion pumps. The Q-switched ruby laser emitted pulses of 30 ns duration with a repetition rate of 4 per minute. The energy could be controlled and varied between 0.5 and 3.0 J/pulse and measured with a power meter. The target was held at an angle to the incident beam in the centre of the chamber facing the substrate held directly opposite, a typical target–substrate distance being 3–4 cm found to be optimum for avoiding particulate deposition (splattering). The target could be rotated slowly at a few rpm to prevent erosion of the target at a given spot. The number of pulses was varied to give films of thickness 50–100 nm measurable by a Talystep and the deposition rate found accordingly. This can be estimated by analytical and numerical techniques to compare with the experiment. For identical deposition conditions, the rate has been found to depend strongly on the bandgap, showing a maximum for CdTe ($E_g = 1.54$ eV) and to decrease rapidly for semi-metals such as TiN and wide bandgap materials such as BN ($E_g = 6.4$ eV). These results can be explained on the basis of the optical properties and thermal conductivities of semiconductors, except for the anomalous behaviour of SiC.

The physical phenomena that occur when a high power laser beam is incident on a material's surface depends on the laser wavelength, power density, the absorptivity of the material at the laser wavelength and its thermal properties such as thermal conductivity κ, diffusivity D_p and heat capacity c. In the case of pulsed laser processing, the heating and cooling cycles are short with a small volume of the target quickly being brought to boiling temperature. After the cessation of the pulse, the volume cools off rapidly due to thermal conduction into the bulk. The short times involved are insufficient for substantial loss of energy due to atomic diffusion. Thus for a given length of time, the surface is heated to a depth determined by the thermal diffusivity of the target.

There are two distinct conditions depending on the given factors.