Fat is an important dietary component which affects both growth and health. It is widely accepted that a high level of fat in the diet is detrimental to health, while recommendations for lower dietary fat levels and changes in the pattern of fatty acid consumption are regularly made.1,2 In recent years there has been an increased focus on replacing some of the individual saturated fat intake with polyunsaturated fat. 3 It has been demonstrated that fatty acid composition of intestinal brush border, basolateral and microsomal membranes can be altered by dietary variation of saturated and polyunsaturated fat.4–8 Further, it has been suggested that lipid composition and functional activities of the biological membranes can be modified by diets varying in fatty acid composition.9–11 If it is true that ‘membranes do what their lipids tell them’, then the lipid components of biological membranes are the main determinants of their physicochemical properties. Indeed, polyunsaturated fatty acids have been reported as playing an important role in regulating the physicochemical properties of the intestinal epithelial membrane.12 Evidence has suggested that transport of nutrients from the lumen to the interior of the gastrointestinal epithelium is regulated by physicochemical properties of the brush border membrane. Similarly, the exit of absorbed nutrients from the enterocyte to the circulatory system is governed by basolateral membrane properties.13–15

Many important cell functions such as transport processes are affected by modulation of the activities of the membrane enzymes through changing of fatty acyl unsaturation. Such unsaturation has been reported to be induced in the membranes of cells when subjected to dietary fat supplementation. A significant proportion of this unsaturated fatty acyl moiety in mammalian cell membranes is required to maintain a ‘fluid’ state for the proper activity of a number of membrane proteins, such as (Na+ + K+)-ATPase, Ca2+-ATPase and Mg2+-ATPase. Moreover, Ca2+ transference efficiency is also affected by high lipid diets in infants16 and in rats.17–19

Thus, we investigated how saturation and unsaturation characters of the different edible oils influence the various physiological phenomena; namely, intestinal transference of Ca2+ and the activities of relevant enzymes, alkaline phosphatase (AP) and Ca2+-ATPase, and the relation of this to determining bone loss in ovariectomized rats.

Intestinal transference of calcium and rate of bone turnover were evaluated in ovariectomized rats fed for 15 days with a high amount (30%) of lipid enriched with monounsaturated (groundnut oil), polyunsaturated (sunflower oil) and saturated (coconut oil) fatty acids. The results were compared with those for sham-operated control and ovariectomized groups fed a normal diet (7% groundnut oil). Irrespective of the saturation and unsaturation characteristics, all lipids (edible oils) used in our study considerably decreased the rate of in situ intestinal transference of calcium. Likewise, the activities of intestinal mucosal enzymes, alkaline phosphatase (AP) and calcium ATPase (Ca2+-ATPase) were decreased significantly in all the segments of the small intestine in a descending gradient. Significant changes in bone turnover and bone calcium (Ca) mobilization were confirmed in these animals by marked alterations in plasma AP activity, urinary calcium and phosphate excretion and calcium to creatinine (Ca:creatinine) ratio. Lipid supplementation (30%) in such ovariectomized rats using groundnut oil (monounsaturated), sunflower oil (polyunsaturated) or coconut oil (saturated) for 15 days further enhanced all of the above observed parameters. These results suggest that the intake of high amounts of lipids with different unsaturation and saturation characteristics may be an important factor in determining bone loss in ovariectomized rats.

Key words: ovariectomy, high lipid diet, oils, saturated, unsaturated, intestinal, epithelium, calcium, bone turnover, osteoporosis.
bone turnover in an ovariectomized rat model of osteoporosis.

Materials and methods

Animals and diets

Female Wistar rats weighing 120–150 g were used for this study. They were housed in an environmentally controlled animal laboratory after being divided into five groups consisting of five rats (randomly selected) in each group: (A) sham-operated control; (B) bilaterally ovariectomized; (C) ovariectomized maintained on a sunflower oil (high polyunsaturated) enriched diet; (D) ovariectomized maintained on a groundnut oil (high monounsaturated) enriched diet; (E) ovariectomized maintained on a coconut oil (high saturated) enriched diet.

Under light ether anaesthesia, bilateral (dorsolateral) ovariectomies were performed in the groups B, C, D and E and animals of group A were subjected to sham-operation. The animals of all groups were provided with a control diet composed of 71% carbohydrates (equal parts of arrowroot starch and sucrose), 18% protein (casein), 7% fat (groundnut oil) and 4% salt mixture, while vitamins were supplied according to Chatterjee et al.²¹ The animals were maintained on this diet for 1 week after the operation. After 1 week, the animals of group C, D and E were supplied with a high-lipid diet²³ for 15 days, while groups A and B were provided with a normal diet. The composition of the high-lipid diet included 48% carbohydrates (equal parts of arrowroot starch and sucrose) and 30% fat (sunflower oil for group C, groundnut oil for group D and coconut oil for group E). The other ingredients of the diet and the supply of vitamins were the same as described above.²⁰–²²

The percentage composition of fatty acids²³ of the normal and high-lipid diets supplied to the various groups of animals in the present investigation are shown in Table 1. The animals of all the groups were provided with a control diet for 15 days, while groups A and B were provided with a normal diet. The composition of the high-lipid diet included 48% carbohydrates (equal parts of arrowroot starch and sucrose) and 30% fat (sunflower oil for group C, groundnut oil for group D and coconut oil for group E). The other ingredients of the diet and the supply of vitamins were the same as described above.²⁰–²²

Preparation of intestinal loops

After the experimental period was over, the body weights of all animals were recorded. They were fasted for 16 h and then anaesthetized with urethane (1.7 mg/g body weight). The preparation of intestinal loops for the study of Ca²⁺ transfer-

### Table 1. Percentage composition of fatty acids of the normal and high lipid diets supplied to the various groups of animals in the present investigation

<table>
<thead>
<tr>
<th>Groups</th>
<th>C4–12</th>
<th>C14</th>
<th>C4–16</th>
<th>C18</th>
<th>C16:1</th>
<th>Oleic acid</th>
<th>Essential linoleic acid C18:2</th>
<th>Fatty acids and other polyunsaturated acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A*</td>
<td>–</td>
<td>trace</td>
<td>9</td>
<td>3</td>
<td>trace</td>
<td>65</td>
<td>17</td>
<td>trace</td>
</tr>
<tr>
<td>Group B*</td>
<td>–</td>
<td>trace</td>
<td>9</td>
<td>3</td>
<td>trace</td>
<td>65</td>
<td>17</td>
<td>trace</td>
</tr>
<tr>
<td>Group C*</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>14</td>
<td>73</td>
<td>1</td>
</tr>
<tr>
<td>Group D*</td>
<td>–</td>
<td>trace</td>
<td>9</td>
<td>3</td>
<td>trace</td>
<td>65</td>
<td>17</td>
<td>trace</td>
</tr>
<tr>
<td>Group E*</td>
<td>63</td>
<td>18</td>
<td>9</td>
<td>2</td>
<td>–</td>
<td>8</td>
<td>1.6</td>
<td>–</td>
</tr>
</tbody>
</table>

Group A, normal diet containing 7% groundnut oil; Group B, normal diet containing 7% groundnut oil; Group C, high lipid diet containing 30% sunflower oil; Group D, high lipid diet containing 30% groundnut oil; Group E, high lipid diet containing 30% coconut oil. *In addition, animals of all groups received an extra 0.1% fatty acid only from arrowroot.
essentially following the method described by Lowry et al.29
The activity of Ca\textsuperscript{2+}-ATPase was studied according to the
method of Rorive and Kleinzeller.30 Phosphate liberated during
enzyme activity was estimated by the method of Lowry and
Lopez.31

**Estimation of urinary calcium, phosphate and creatinine**

Urine was collected for 24 h (8 a.m. to 8 a.m.) according to the
standard laboratory procedure,32 as described elsewhere by Chanda et al.33 Care was taken so that no urine was lost
through evaporation. Total volume was measured. Ca\textsuperscript{2+},
phosphate and creatinine content of urine were estimated according to the methods described, respectively, by Adeniyi et al.,26 Lowry and Lopez31 and Nath.34

**Estimation of plasma calcium and alkaline phosphatase**

Blood was collected directly from the heart under urethane
anaesthesia (1.7 mg/g body weight). Heparin was used as an
anticoagulant. Plasma Ca\textsuperscript{2+} was estimated using the method of Adeniyi et al.26 For estimation of plasma AP activity, the method described by Maenz and Cheeseman27 was essen-
tially followed.

**Data**

Data were expressed as mean ± SE. Statistical significance
was determined using the one way analysis of variance
(ANOVA) unless otherwise mentioned for Student’s t-test.
P < 0.05 was considered to be significant.

**Results**

**Mucosal calcium transference profiles**

The mucosal calcium transference profiles in the different
intestinal segments of ovariectomized rats supplemented
with different kind of edible oils are shown in Table 2. In
order to ascertain whether calcium transference in the sham-
operated control and hypo gonadal (ovariectomized) states have any significant difference, we analysed the results of Student’s t-tests of Group A and Group B and found significant (P < 0.05) differences. Note further that in the hypo-
gonadal state, when high lipid was supplemented in the diet
either with sunflower, groundnut or coconut oil, a greater
decrease in mucosal transference of calcium in all segments
was observed compared with the hypo gonadal (ovari-
ectomized) state alone.

**Mucosal alkaline phosphatase activity profiles**

The mucosal alkaline phosphatase activity profiles in the dif-
ferent intestinal segments of ovariectomized rats supra-
mplemented with different kind of edible oils are shown in Table
3. Similar to calcium transference results, alkaline phos-
phatase activity also showed significant (P < 0.05) differ-
ences in the sham-operated control and hypogonadal
(ovariectomized) states. High lipid diet supplemented groups
were found to be more prone to greater decreases in alkaline
phosphatase activity in all segments of the hypogonadal rats.

**Mucosal calcium ATPase activity profiles**

The mucosal calcium ATPase activity profiles in the different
intestinal segments of ovariectomized rats supplemented
with different kinds of edible oils are shown in Table
4. Similar to mucosal calcium transference and alkaline phos-
phatase activity, mucosal calcium ATPase activity was also
reduced in all high lipid diet supplemented groups and in all
segments of the intestine, compared with the sham-operated
control and hypogonadal (ovariectomized) state groups. A
significant (P < 0.05, Student’s t-test) difference of calcium

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**Table 2. Mucosal transference of Ca\textsuperscript{2+} in duodenal, jejunal and ileal segments of sham-control (Group A), ovariectomized (Group B), ovariectomized + sunflower oil fed (Group C), ovariectomized + groundnut oil fed (Group D) and ovariectomized + coconut oil fed (Group E) rats**

<table>
<thead>
<tr>
<th>Segments of small intestine</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
<th>Group E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duodenum</td>
<td>7.65 ± 0.37</td>
<td>6.64 ± 0.29</td>
<td>6.15 ± 0.05</td>
<td>5.90 ± 0.11</td>
<td>5.77 ± 0.20</td>
</tr>
<tr>
<td>Jejunum</td>
<td>7.27 ± 0.20</td>
<td>6.44 ± 0.15</td>
<td>6.12 ± 0.08</td>
<td>5.85 ± 0.10</td>
<td>5.73 ± 0.19</td>
</tr>
<tr>
<td>Ileum</td>
<td>6.44 ± 0.28</td>
<td>5.52 ± 0.32</td>
<td>4.85 ± 0.15</td>
<td>4.70 ± 0.20</td>
<td>4.64 ± 0.33</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± SE (n = 5). Ca\textsuperscript{2+} is expressed in mmol/g dry weight/h. Pa, Significance based on F value and one-way analysis of variance groups A, B, C, D and E. Pb, Significance based on F value and one-way analysis of variance groups B, C, D and E. Pc, Significance based on F value and one-way analysis of variance groups C, D and E.

**Table 3. Alkaline phosphatase activity of intestinal mucosal extracts in duodenal, jejunal and ileal segments of sham-control (Group A), ovariectomized (Group B), ovariectomized + sunflower oil fed (Group C), ovariectomized + groundnut oil fed (Group D) and ovariectomized + coconut oil fed (Group E) rats**

<table>
<thead>
<tr>
<th>Segments of small intestine</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
<th>Group E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duodenum</td>
<td>237.4 ± 12.9</td>
<td>167.3 ± 10.8</td>
<td>161.0 ± 4.6</td>
<td>158.9 ± 5.3</td>
<td>146.0 ± 2.7</td>
</tr>
<tr>
<td>Jejunum</td>
<td>151.1 ± 7.5</td>
<td>116.4 ± 4.2</td>
<td>107.0 ± 2.4</td>
<td>104.6 ± 1.4</td>
<td>100.0 ± 6.5</td>
</tr>
<tr>
<td>Ileum</td>
<td>85.5 ± 2.7</td>
<td>65.3 ± 2.2</td>
<td>55.0 ± 4.8</td>
<td>52.7 ± 4.5</td>
<td>51.0 ± 6.5</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± S.E. (n = 5). Alkaline phosphatase activity is expressed as \( p \)-nitrophenol liberated in µmol/g protein/min at 37°C. Pa, significance based on F value and one-way analysis of variance groups A, B, C, D and E. Pb, Significance based on F value and one-way analysis of variance groups B, C, D and E. Pc, Significance based on F value and one-way analysis of variance groups C, D and E.
ATPase activity was also observed between sham-operated control and hypogonadal state groups.

**Plasma calcium and alkaline phosphatase activity profiles**

The plasma calcium and alkaline phosphatase activity profiles of ovariectomized rats supplemented with different kind of edible oils are shown in Table 5. Compared with the sham-operated controls, ovariectomized animals showed a significant ($P < 0.05$, Student’s $t$-test) increase in alkaline phosphatase activity. Similar increases in plasma AP activity were also noted when ovariectomized animals were supplemented with different kind of edible oils. Plasma calcium level, however, did not show any significant alteration under the conditions of our study.

**Urinary calcium and phosphate excretion profiles and calcium to creatinine ratio**

The urinary calcium and phosphate excretion profiles and calcium to creatinine ratio of ovariectomized rats supplemented with different kind of edible oils are shown in Table 6. Compared with sham-operated controls, ovariectomized animals showed a significant ($P < 0.05$, Student’s $t$-test) increase in all three of the parameters. The increases in all parameters were further pronounced when ovariectomized animals were supplemented with different kind of edible oils, of which coconut oil was found to be most effective in producing these changes.

**Table 4.** Calcium ATPase activity of intestinal mucosal extracts in duodenal, jejunal and ileal segments of sham-control (Group A), ovariectomized (Group B), ovariectomized + sunflower oil fed (Group C), ovariectomized + groundnut oil fed (Group D) and ovariectomized + coconut oil fed (Group E) rats

<table>
<thead>
<tr>
<th>Segments of small intestine</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
<th>Group E</th>
<th>Significant level Pa</th>
<th>Pb</th>
<th>Pc</th>
<th>AvB</th>
<th>BvC</th>
<th>BvD</th>
<th>BvE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duodenum</td>
<td>16.3 ± 0.66</td>
<td>13.8 ± 0.32</td>
<td>12.9 ± 0.32</td>
<td>11.2 ± 0.63</td>
<td>9.5 ± 0.75</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>15.3</td>
<td>6.52</td>
<td>18.84</td>
<td>31.16</td>
</tr>
<tr>
<td>Jejunum</td>
<td>11.4 ± 0.74</td>
<td>8.8 ± 0.25</td>
<td>8.3 ± 0.09</td>
<td>8.0 ± 0.27</td>
<td>7.1 ± 0.33</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>22.8</td>
<td>5.68</td>
<td>9.09</td>
<td>19.32</td>
</tr>
<tr>
<td>Ileum</td>
<td>7.7 ± 0.33</td>
<td>6.1 ± 0.33</td>
<td>5.5 ± 0.08</td>
<td>5.3 ± 0.16</td>
<td>4.7 ± 0.09</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>20.8</td>
<td>9.84</td>
<td>13.11</td>
<td>22.95</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± SE ($n = 5$). Calcium ATPase activity is expressed as phosphate liberated in mmol/g protein/min at 37°C. Pa, Significance based on F value and one-way analysis of variance groups A, B, C, D and E. Pb, Significance based on F value and one-way analysis of variance groups B, C, D and E. Pc, Significance based on F value and one-way analysis of variance groups C, D and E.

**Table 5.** Plasma biochemistry of sham-control (Group A), ovariectomized (Group B), ovariectomized + sunflower oil fed (Group C), ovariectomized + groundnut oil fed (Group D) and ovariectomized + coconut oil fed (Group E) rats

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
<th>Group E</th>
<th>Significant level Pa</th>
<th>Pb</th>
<th>Pc</th>
<th>AvB</th>
<th>BvC</th>
<th>BvD</th>
<th>BvE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Ca}^{2+}$ (mg/dL)</td>
<td>7.12 ± 0.11</td>
<td>7.20 ± 0.35</td>
<td>7.34 ± 0.10</td>
<td>7.38 ± 0.18</td>
<td>7.58 ± 0.10</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>1.12</td>
<td>2.0</td>
<td>2.50</td>
<td>5.30</td>
</tr>
<tr>
<td>AP (U/L)</td>
<td>109.0 ± 5.12</td>
<td>136.0 ± 5.66</td>
<td>156.0 ± 4.55</td>
<td>162.0 ± 4.53</td>
<td>169.0 ± 6.54</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>24.8</td>
<td>14.7</td>
<td>19.1</td>
<td>24.3</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± SE ($n = 5$). NS denotes not significant. Pa, Significance based on F value and one-way analysis of variance groups A, B, C, D and E. Pb, Significance based on F value and one-way analysis of variance groups B, C, D and E. Pc, Significance based on F value and one-way analysis of variance groups C, D and E. Ap, alkaline phosphatase.

**Table 6.** Urine biochemistry of sham-control (Group A), ovariectomized (Group B), ovariectomized + sunflower oil fed (Group C), ovariectomized + groundnut oil fed (Group D) and ovariectomized + coconut oil fed (Group E) rats

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
<th>Group E</th>
<th>Significant level Pa</th>
<th>Pb</th>
<th>Pc</th>
<th>AvB</th>
<th>BvC</th>
<th>BvD</th>
<th>BvE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphat (mg)</td>
<td>35.6 ± 2.4</td>
<td>45.5 ± 2.2</td>
<td>50.5 ± 1.2</td>
<td>56.9 ± 2.7</td>
<td>59.5 ± 2.9</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>27.80</td>
<td>10.99</td>
<td>24.90</td>
<td>30.80</td>
</tr>
<tr>
<td>$\text{Ca}^{2+}$ (mg)</td>
<td>3.27 ± 0.08</td>
<td>9.61 ± 0.55</td>
<td>10.8 ± 0.14</td>
<td>11.2 ± 0.28</td>
<td>11.92 ± 0.20</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>194.00</td>
<td>11.97</td>
<td>17.00</td>
<td>24.04</td>
</tr>
<tr>
<td>Ca:Cr ratio (mg:mg)</td>
<td>1.70 ± 0.13</td>
<td>2.43 ± 0.07</td>
<td>2.68 ± 0.10</td>
<td>2.74 ± 0.07</td>
<td>2.82 ± 0.07</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>42.90</td>
<td>10.30</td>
<td>12.80</td>
<td>16.00</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± SE ($n = 5$). Urinary calcium (Ca) and creatinine (Cr) excretion is expressed in mg/24 h urine. Urinary phosphate excretion is expressed in mg/dL. Pa, Significance based on F value and one-way analysis of variance groups A, B, C, D and E. Pb, Significance based on F value and one-way analysis of variance groups B, C, D and E. Pc, Significance based on F value and one-way analysis of variance groups C, D and E.
Our data further indicate that such inhibition of Ca\(^{2+}\) transference by addition of high amounts of lipids in the diet possibly depends upon the degree of unsaturation and saturation characteristics of the lipids (Table 2). Saturated fat (coconut oil) produced a more pronounced (\(P < 0.001\)) decrease in Ca\(^{2+}\) transference compared with mono-unsaturated (groundnut oil) or polyunsaturated fat (sunflower oil). It has been reported that dietary fat affects lipid and fatty acid composition of biological membranes, including the microvillus membrane.\(^{5,7,8}\) It has also been reported that many important cell functions such as transport processes are affected by modulation of the activities of the membrane enzymes, namely Na\(^+\)-K\(^+\)-ATPase, Ca\(^{2+}\)-ATPase and Mg\(^{2+}\)-ATPase, through changing fatty acyl unsaturation.\(^{9}\) An increase in such unsaturation has often been considered necessary for increased membrane fluidity.\(^{7}\) It is therefore plausible that in our study the addition of high amounts of lipids in the diet with different degrees of saturation and unsaturation characters had an influence on membrane unsaturation, thus affecting membrane protein activity and resulting in the inhibition of Ca\(^{2+}\) transference.

Ca\(^{2+}\) transference in our study showed segmental variation and was seen to have a descending gradient from the duodenum to ileum irrespective of groups (Table 2). This corroborates well with the earlier observation of Wills.\(^{35}\) Our results further suggest that ovarian hormones possibly have an influence on the intestinal transference of Ca\(^{2+}\) given that bilaterally ovariectomized rats, compared with sham-operated control, showed a significant decrease in the transference of Ca\(^{2+}\).

Our studies with AP and Ca\(^{2+}\)-ATPase suggest that, irrespective of groups, both these enzymes showed segmental variation in their activities in the rat small intestine (Tables 3 and 4). This confirms the earlier observation of Toofanian and Teshfam.\(^{36}\) Results further revealed that, compared with controls, activities of both of these enzymes were significantly inhibited in bilaterally ovariectomized rats as well as in rats of different groups in which high amount of lipids were added in the diet. These results suggest that the possible cause of reduction of Ca\(^{2+}\) transference in our study might be an inhibition of activities of these enzymes as both the enzymes have been reported to be involved in Ca\(^{2+}\) transference. Our results also indicate that AP and Ca\(^{2+}\)-ATPase may make a significant contribution to the regulation of intestinal transference of Ca\(^{2+}\). Our results thus confirm the earlier proposal of Wasserman and Fullmer that AP and Ca\(^{2+}\)-ATPase make a significant contribution to the regulation of intestinal transference of Ca\(^{2+}\).\(^{37}\)

Compared with sham-operated controls, bilaterally ovariectomized rats showed an increased loss of urinary Ca and phosphate. This loss was further enhanced when these animals were fed with diets enriched with high amounts of lipids (Table 6). Compared with sham-operated controls, bilaterally ovariectomized rats did not have an altered plasma Ca level. This observation is in agreement with an earlier report by Lindsay et al.\(^{38}\) The plasma Ca level also was not changed when ovariectomized animals were fed with diets containing different edible oils (Table 5).

Thus, with respect to Ca homeostasis our results suggest that the experimental conditions of the present study may be highly conducive for the development of a hypocalcemic condition. This suggestion has its own merit as an increased urinary loss of Ca, as occurred in our study, has always been associated with a simultaneous decrease in intestinal transference of Ca\(^{2+}\). These factors are two of the most important for the development of hypocalcemia and secondary increase in parathormone secretion.\(^{39,40}\)

Biochemical markers of bone turnover, namely plasma AP activity and urinary Ca to creatinine ratio, were found to be enhanced when ovariectomized animals were fed with high amounts of lipids in their diets. A rise in serum AP and the urinary Ca to creatinine ratio has been linked with collagen degradation, bone resorption and osteoporosis.\(^{38,41–43}\) Thus, the positive influence of high lipid supplementation on bone turnover and bone loss, under the conditions of the present study, is apparent.

The observations made in the present investigation may have far reaching implications should bone loss be assessed in light of dietary habits, such as the preference of using one kind of edible oil over the others. This is because many dietary components have an important biochemical and physiological impact for a healthy life, particularly in women of menopausal age.

**Acknowledgement.** The financial assistance of the University Grants Commission (UGC), New Delhi, India is gratefully acknowledged.

**References**