GUSTATORY PREFERENCES DURING ESTRUS CYCLE IN RATS

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Summary: Estrus cycle has been used as a base to study gustatory responses in rats under conditions of two-bottle choice test given for one hour daily, and the data pooled respectively for diestrus/metestrus (D/M) and proestrus/estrus (P/E).

Glucose (13.5%), sodium saccharin (0.2%), sodium chloride (0.9%), citric acid (0.004%) and quinine sulphate (0.03%) was each paired with water and a particular solution was presented daily for one week. Two days gap was given between two different solutions when only water was made available in both the bottles. An increased preference for glucose and saccharin, decrease to sodium chloride and no change in citric acid and quinine sulphate was observed at P/E. The differential gustatory responses is perhaps linked to the levels of ovarian and hypophyseal hormones at the time of ovulation.

Key words: estrus cycle gustatory response ovulation ovarian and hypophyseal hormones

INTRODUCTION

Sensuality, behaviour and activity undergo a change with reproductive cyclicity in many species. Gonadal hormones influence palatability and spontaneous ingestion of a number of sweet solutions (28). Female rats (19,20,21,8), hamsters (29) and human infants (16) consume sweet solutions in greater quantities than do their male counterparts. The difference in ingestion of sweet solutions is thought to be caused by a stimulatory influence of ovarian hormones on the taste regulatory mechanisms (22, 28).

Wade and Zucker (22) reported that the female rats treated with androgen during the period critical for sexual differentiation of reproductive behaviour markedly depressed the saccharin preference in adulthood. It has been observed that estradiol and progesterone act synergistically but not singly to elevate the saccharin preference of spayed rats and hamsters (28,29) and an optimal balance of estrogen and progesterone is essential for the maintenance of maximal reactivity to both positively and negatively reinforcing taste stimuli (24). Saccharin preference and quinine aversions were markedly diminished by withdrawal of ovarian hormones and could be restored in ovariectomised rats by estradiol benzoate and progesterone replacement therapy (28).

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Thus while a large amount of data on gustatory responses are available on the influence of exogenous hormones in gonadectomised animals, very little information is available on the gustatory response change during normal estrus cycle in rats. The present study was undertaken to see whether the fluctuating levels of hormones during the normal estrus cycle would influence the animals’ taste responses to both nutritive and non-nutritive substances used as gustatory stimuli, and if the gustatory responses have any correlation with the onset of ovulation.

MATERIALS AND METHODS

Sexually mature female albino rats of CFTRI strain weighing between 130-170 g at the beginning of the experiment form the basis of the present study. The rats were housed in individual cages and the temperature of the animal house was 24 ± 2°C. The diurnal rhythm of light and darkness each of about 1200 hours duration was maintained. The rats were fed on ad lib supply of laboratory food pellets (Hindustan Lever) and water. Body weight, food, and water intake were recorded daily. Vaginal smears were examined daily at 0900 hours to assess the various phases of the estrus cycle. After observing over a period of four weeks, 10 rats having regular cycles were selected for the rest of the experiment.

The animals were offered a one-hour two-bottle choice of fluids, one containing the test solution and the other the tap water. A particular test solution was presented every day for one week. Two days gap was given between two different solutions when only water was made available in both the bottles. The drinking bottles were alternated to avoid the possible position effect. Preference for the solution was calculated by taking the solution/water ratio.

The food intake, water intake, and fluid intake readings were corrected for the body weight and expressed as per 100 g body weight. For the final analysis, the data obtained were pooled separately for diestrous-indicating the beginning and metestrus-indicating the completion of estrus cycle (D/M), and proestrus and estrus-around ovulation (P/E). The various test solutions used were prepared in distilled water and consisted of glucose (13.5%), sodium saccharin (0.2%), sodium chloride (0.9%), citric acid (0.004%) and quinine sulphate (0.002%).

RESULTS

The mean body weight, food intake, and water intake are presented in Table I. Rats during P/E showed a highly significant (P<0.001) decrease in the body weight as compared to the D/M stages. The change in the food intake paralleled the changes in the body weight and the differences were significant (P<0.001). The 24-hour water intake also
showed a similar decrease during P/E but the values corrected to per 100 g body weight did not show any significant change between the various phases.

Table II indicates the solution and water consumption during the one hour test. The preference for the various solutions over water during the various phases of the estrus cycle are shown in (Fig. 1).

### TABLE I: Mean body weight (gms), food intake (gms), and water intake (ml) \( \pm SE/100 \text{ gm body weight during Estrus Cycle in rats.} \)

<table>
<thead>
<tr>
<th></th>
<th>Diestrus/Metestrus</th>
<th>Proestrus/Estrus</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight</td>
<td>173.65±1.31</td>
<td>167.13±1.45</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Food</td>
<td>7.70±0.20</td>
<td>7.41±0.092</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Water</td>
<td>15.80±0.33</td>
<td>15.87±0.001</td>
<td>&lt;0.2**</td>
</tr>
</tbody>
</table>

*Highly significant
**Not significant

Figures in parentheses represent the number of observations.

### TABLE II: One hour solution and water intake (mean±SE)/100 gm body weight during estrus cycle in rats.

<table>
<thead>
<tr>
<th>Solution</th>
<th>Diestrus/Metestrus</th>
<th>Proestrus/Estrus</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.5% Glucose</td>
<td>4.79±0.32</td>
<td>4.21±0.16</td>
<td>5.92</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Water</td>
<td>0.38±0.08</td>
<td>0.14±0.03</td>
<td>6.94</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>(34)</td>
<td>(81)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2% Sodium saccharin</td>
<td>3.80±0.40</td>
<td>3.04±0.23</td>
<td>6.89</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Water</td>
<td>0.42±0.12</td>
<td>0.25±0.04</td>
<td>5.15</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>(34)</td>
<td>(70)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9% Sodium chloride</td>
<td>2.13±0.24</td>
<td>1.82±0.15</td>
<td>4.21</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Water</td>
<td>0.34±0.06</td>
<td>0.33±0.01</td>
<td>1.87</td>
<td>&lt;0.1 (ns)</td>
</tr>
<tr>
<td></td>
<td>(40)</td>
<td>(76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.004% Citric acid</td>
<td>0.46±0.09</td>
<td>0.53±0.06</td>
<td>1.94</td>
<td>&lt;0.1 (ns)</td>
</tr>
<tr>
<td>Water</td>
<td>0.50±0.07</td>
<td>0.39±0.03</td>
<td>5.00</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>(28)</td>
<td>(75)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.002% Ouinine sulphate</td>
<td>0.104±0.04</td>
<td>0.142±0.02</td>
<td>2.23</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Water</td>
<td>0.32±0.06</td>
<td>0.33±0.03</td>
<td>0.40</td>
<td>&gt;0.2 (ns)</td>
</tr>
<tr>
<td></td>
<td>(23)</td>
<td>(73)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significance level P<0.05
*Highly significant
Figures in parentheses represent the number of observations.
Glucose and water: With both glucose and water available in the two-bottle choice situations, rats consumed less quantities of glucose and water during P/E as compared to values obtained during D/M (Table II). The difference is highly significant (P<0.001). The preference for glucose is 30 times over water at P/E as compared to 12 times at D/M (Fig. 1).

Saccharin and water: A significant decrease (P<0.001) in the intake of saccharin (3.04±0.23 ml/100 g body weight) and water (0.25±0.04 ml/100 g body weight) is seen during P/E, the values for saccharin and water being (3.80±0.40 ml/100 g body weight) and (0.42±0.12 ml/100 g body weight) respectively at D/M. The preference for saccharin at P/E is 12 times over water as compared to 9 times at D/M.
Sodium chloride and water: Rats during P/E consumed significantly decreased (P<0.001) amount of sodium chloride as compared to the intake at D/M. The water intake showed a slight but non-significant decrease (0.33±0.01 ml/100 g body weight) at P/E as compared to the values (0.34±0.06 ml/100 g body weight) at D/M. The preference for sodium chloride is 5.9 times over water at P/E while it is 6.3 times over water at D/M stages.

Citric acid and water: When citric acid and water were paired together P/E rats showed a slight non significant increase in the intake of citric acid as compared to the intake at D/M. However, a significant (P<0.001) decrease in the water intake is seen at P/E as compared to the intake at D/M. The preference for citric acid at P/E is 1.35 times over water as compared to 0.92 times at D/M.

Quinine and water: P/E rats showed a slight increase in the quinine intake (P<0.05) as compared to the intake at D/M. No significant change in the water intake is seen between the various phases. The preference for quinine over water during P/E is 0.43 times as compared to 0.32 times at D/M.

Water and water: With water as the only available solution in both the bottles during the one hour test, rats showed a non-significant decrease in the intake at P/E as compared to D/M.

DISCUSSION

It is clear from the results that the body weight, food intake and water intake decreased during P/E phases (Table I). Plasma concentration of gonadotrophin and ovarian hormones throughout the four day cycle of the rat has been well documented (5). The role of ovarian hormones in regulation of the body weight of female rats has been studied extensively. Late proestrus, the stage of estrus cycle during which the sexual receptivity occurs and which follows peak levels of blood plasma estradiol-17-$\beta$ (5), is accompanied by a suppression in daily food intake (4, 17) relative to diestrus levels. This decrease in energy intake, along with a correlated increase in the energy expenditure (7,27) results in a net body weight decrease during proestrus (4). Withdrawal of gonadal steroids by ovariectomy results in an increase in food intake and a concomitant increase in the body weight (17). It is also known that systemic injection of estradiol-17-$\beta$ (15,18) or local implants in the area of the ventromedial hypothalamus (3,11,23) reverses these effects resulting in a decrease in food intake and decreased body weight.

Tartellin et al. (17) associated the cyclic suppression of food intake with the neuroendocrine events related to ovulation and suggested that the levels of estrogen which peak shortly before the afternoon of vaginal proestrus could provide a suitable stimulus to inhibit
food intake during the dark period. It has been suggested that estradiol may act on the 
(VMH) to depress food intake in the intact female rat (25,26,23) or the effect may be due 
to the alterations in the gastrointestinal motility or stomach emptying.

The present study further indicates that the rats showed a strong preference for glu­
cose and saccharin during P/E inspite of the fact that the solution intake as well as the water 
intake during the test period decreased. A decrease in the total fluid intake during estrus 
when water was offered in both the bottles has been reported (1). Females have been 
seen to consume more glucose as compared to their male counterparts (19,20,21). Our 
results of an earlier study (12) using a single bottle test indicated an increased intake of 
glucose/saccharin at P/E. Recent studies (6) on taste intensity and taste hedonics during 
menstrual cycle in human females showed the existence of a linear relationship between the 
taste intensity and the strength of glucose solutions. The pleasantness ratings, however, 
varied during the different phases of the menstrual cycle. The values for sweet preference 
were less during menstruation and preovulatory phase and high at ovulation. Similar re­
results have been obtained in the present study which seem to show a parallel of enhanced 
preference for sweet substances during ovulation in rats.

Working on the taste preferences for salt solutions in rat, Krecek et al., (14) found 
no sex difference for the intake until the period of sexual maturation, but with the onset of 
sexual maturity the females drank more of salt solution than males. Our results indicate a 
variation in the preference for salt during the estrus cycle with a decreased preference at 
P/E. There appears to be no change in the preference for citric acid and quinine during the 
various phases (Fig. 1). The reason for such differential response are unclear.

Although it is not known whether ovarian hormones act directly on the brain to 
alter the taste preferences, it is interesting to note that some of the same neural regions that 
take up estradiol and effect eating may also affect taste preferences (2,9,13). Sex steroids 
could also act on peripheral taste receptors to affect taste sensitivity (10). Perhaps the 
changes in taste preferences that accompany the various reproductive states reflect some 
hedonic mechanism for regulating the selection of the dietary components under differant 
conditions of nutritive needs (25).

It may seem that the increased levels of ovarian and hypophyseal hormones at the 
time of ovulation might be acting synergistically to alter the taste sensitivity or taste hedo­
nics or both and may be linked to the increased preference seen for glucose and saccharin, 
decrease to sodium chloride and no change in citric acid and quinine sulphate.
ACKNOWLEDGEMENTS

Grateful acknowledgement is made to St. John's Medical College Research Society for providing financial assistance.

REFERENCES


