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# The Effects of Energy Increasing and Protein Lowering by Addition of Fats to Diet on Broiler Chickens: Performance and Serum Lipids

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**Abstract:** This experiment was conducted to determine the effects of increasing, energy to protein ratio and partial decreasing of nutrient contents of diet using different levels of fats on broiler chickens performance and serum lipids. With addition of fats (Poultry oil, Soybean oil and Tallow) in two levels (4 or 8%) to basal diet that was already balanced on NRC (1994) recommendations, seven different non-isocaloric and non-isonitrogenic diets were prepared (12 or 24% increasing of energy to protein ratio in 4 or 8% of fat level addition, respectively) and given *ad libitum* between 22 to 49 day of age. The blood samples were collected at 35 and 49 day and weight of selected visceral organs were recorded at 49 day. The results suggested that high fat intake had no significant effect on Final Body Weight (FBW) and Feed Conversion Ratio (FCR). Numerically the FBW was higher in all groups that received high fat levels than control group. But abdominal fat deposition only in birds that was fed by additional soybean oil and tallow in 4% level was constant. The liver weight significantly decreased ($p<0.01$) and abdominal fat weight significantly increased ($p<0.05$) by elevation of fat level. Serum lipids concentrations had no significant difference in dietary treatments. Serum LDL concentration showed significant elevation from 35 to 49 day ($p<0.01$), whereas serum cholesterol concentration showed decline at the same times ($p<0.05$). With increasing of dietary fat level from 4 to 8%, serum cholesterol had showed elevation ($p<0.05$). Therefore, it seems that broilers are more resistant against the high dietary fat intake and they can be effectively used for nutritional and growth requirements promoting, without mortality.

**Key words:** Broiler chicken, fat, performance, serum lipid

## INTRODUCTION

Fats have been shown to be a practical and economical means by which to increase energy levels in poultry diets and growth stimulates (Griminger, 1986; Latour *et al*., 1994). The large amount accumulation of fat in the abdominal cavity is a problem with new commercial broilers, since modern broilers contains about 150-200 g fat $kg^{-1}$ of body weight and over 85% of it is physiologically non-essential (Sadeghi and Tabiedian, 2005). Other important roles of fats in diet are their inhibition from *de novo* lipogenesis; provide varying quantities of the nutrients such as linoleic acid, vitamins, diet palatability, mechanical and structural roles and low heat increment (Choct *et al*., 2000; Leeson and Summers, 2001). Therefore, the specialists endeavor on the basis of these advantages and defects of dietary fat intake, a functional diet to balanced (Alparslan and Ozdogan, 2006). Serum lipids

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concentrations as metabolical and physiological indicators are affected by dietary fats levels intake. (Peebles *et al*., 1997). All fats, particularly saturated animal fats usually have been used in later phases of feeding, because of limited digestibility in young chicken (Leeson and Summers, 2001). In this study, the relationships between high fats intake with performance values, serum lipids concentrations and weight of visceral organs in male broilers were determined. In the other hand, the responses of broilers body to high energy and low protein diets in comparison to one balanced diet on National Research Council (1994) recommendations were examined. Then, on the basis of the obtained results in case of using rich energy and diluted protein diets can be resolution to optimum securing of nutritional and growth requirements and partial decreasing of feed cost.

## MATERIALS AND METHODS

This study was conducted at Islamic Azad University, Shabestar branch, Shabestar-Iran in summer of 2006. Total of 210 one-day old broiler chicks of the Cobb-500 strain from male sex were randomly assigned in 21 pens. Each bird initially occupied 0.08 $m^2$ of floor space. The pens were randomized with respect to dietary treatment. Birds were provided with continuous light. This experimental design was completely Randomized design, with seven combinations treatment and three replicates. With addition of three types of fats including poultry oil, soybean oil and tallow in two levels (4 or 8%) to basal diet that was already balanced on National Research Council (1994) recommendations. Seven different non-isocaloric and non-isonitrogenic diets were prepared (12 or 24% increasing of energy to protein ratio in 4 or 8% of additional fat level, respectively) and given *ad libitum* at 22 to 49 day old (grower and finisher periods). Total birds were fed a resembling starter diet at 1 to 21 day old. Ingredient percentage and calculated analysis of grower and finisher diets are provided in Table 1 and 2. At 35 and 49 day of age in fasting state, bloods samples were randomly collected from wing vein of one bird per pen and rapidly were centrifuged at 5000 rpm during 5 min and then sera by using commercial kits (Pars Azmun) in auto analyzer (ALCYON 300) were analyzed.

Table 1: Ingredient and calculated analysis of grower diets

| | Diets[1] | | | | | | |
|---|---|---|---|---|---|---|---|
| Ingredients | C | C+4%T | C+4%S | C+4%P | C+8%T | C+8%S | C+8%P |
| | (%) | | | | | | |
| Yellow corn | 70.50 | 67.68 | 67.68 | 67.68 | 64.86 | 64.86 | 64.86 |
| Soybean meal (44%CP) | 19.30 | 18.53 | 18.53 | 18.53 | 17.76 | 17.76 | 17.76 |
| Fish meal (60%CP) | 7.50 | 7.20 | 7.20 | 7.20 | 6.90 | 6.90 | 6.90 |
| Fat | - | 4.00 | 4.00 | 4.00 | 8.00 | 8.00 | 8.00 |
| Oyster shell | 1.40 | 1.34 | 1.34 | 1.34 | 1.29 | 1.29 | 1.29 |
| Mono calcium phosphate | 0.35 | 0.34 | 0.34 | 0.34 | 0.32 | 0.32 | 0.32 |
| DL-methionine | 0.15 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| Sodium chloride | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 |
| Vitamin premix[2] | 0.25 | 0.24 | 0.24 | 0.24 | 0.23 | 0.23 | 0.23 |
| Mineral premix[3] | 0.25 | 0.24 | 0.24 | 0.24 | 0.23 | 0.23 | 0.23 |
| Coccidiostat (Clopidol 25%) | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 |
| Vitamin E | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 |
| **Calculated analysis** | | | | | | | |
| ME (kcal $kg^{-1}$) | 3030.00 | 3249.00 | 3269.00 | 3269.00 | 3468.00 | 3507.00 | 3507.00 |
| CP (%) | 19.00 | 18.24 | 18.24 | 18.24 | 17.48 | 17.48 | 17.48 |
| ME:CP ratio | 159.00 | 178.00 | 179.00 | 179.00 | 198.00 | 200.00 | 200.00 |
| Calcium (%) | 1.12 | 1.08 | 1.08 | 1.08 | 1.03 | 1.03 | 1.03 |
| Available phosphorus (%) | 0.50 | 0.48 | 0.48 | 0.48 | 0.46 | 0.46 | 0.46 |
| Methionine (%) | 0.54 | 0.52 | 0.52 | 0.52 | 0.50 | 0.50 | 0.50 |
| Methionine + Cystine (%) | 0.76 | 0.73 | 0.73 | 0.73 | 0.70 | 0.70 | 0.70 |
| Lysine (%) | 1.09 | 1.05 | 1.05 | 1.05 | 1.00 | 1.00 | 1.00 |

[1]C: Control (basal diet); T: Tallow; S: Soybean oil; P: Poultry oil. [2]Supplemented (For each kg of the diets): Vit. A, 12000 IU; D3, 2000 IU; E, 20 mg; K3, 3 mg; B2, 7 mg; B3, 12 mg; B5, 3 mg; B12, 0.03 mg; Biotin, 0.1 mg; Choline chloride, 300 mg and adequate anti oxidant. [3]Supplemented (For each kg of the diets): Mn, 130 mg; Fe, 70 mg; Zn, 60 mg; Cu,12 mg; I, 1 mg; Se, 0.2 mg

Table 2: Ingredient and calculated analysis of finisher diets

| | Diets[1] | | | | | | |
|---|---|---|---|---|---|---|---|
| Ingredients | C | C+4%T | C+4%S | C+4%P | C+8%T | C+8%S | C+8%P |
| | (%) | | | | | | |
| Yellow corn | 73.40 | 70.46 | 70.46 | 70.46 | 67.53 | 67.53 | 67.53 |
| Soybean meal (44%CP) | 20.50 | 19.68 | 19.68 | 19.68 | 18.86 | 18.86 | 18.86 |
| Fish meal (60%CP) | 2.80 | 2.69 | 2.69 | 2.69 | 2.58 | 2.58 | 2.58 |
| Fat | - | 4.00 | 4.00 | 4.00 | 8.00 | 8.00 | 8.00 |
| Oyster shell | 1.60 | 1.54 | 1.54 | 1.54 | 1.47 | 1.47 | 1.47 |
| Mono calcium phosphate | 0.70 | 0.67 | 0.67 | 0.67 | 0.64 | 0.64 | 0.64 |
| DL-methionine | 0.10 | 0.096 | 0.096 | 0.096 | 0.092 | 0.092 | 0.092 |
| Sodium chloride | 0.10 | 0.096 | 0.096 | 0.096 | 0.092 | 0.092 | 0.092 |
| Vitamin premix[2] | 0.25 | 0.24 | 0.24 | 0.24 | 0.23 | 0.23 | 0.23 |
| Mineral premix[3] | 0.25 | 0.24 | 0.24 | 0.24 | 0.23 | 0.23 | 0.23 |
| Coccidiostat (Clopidol 25%) | 0.10 | 0.096 | 0.096 | 0.096 | 0.092 | 0.092 | 0.092 |
| Vitamin E | 0.10 | 0.096 | 0.096 | 0.096 | 0.092 | 0.092 | 0.092 |
| **Calculated analysis** | | | | | | | |
| ME (kcal $kg^{-1}$) | 3030.00 | 3249.00 | 3269.00 | 3269.00 | 3468.00 | 3507.00 | 3507.00 |
| CP (%) | 17.00 | 16.32 | 16.32 | 16.32 | 15.64 | 15.64 | 15.64 |
| ME:CP ratio | 178.00 | 199.00 | 200.00 | 200.00 | 221.00 | 224.00 | 224.00 |
| Calcium (%) | 0.95 | 0.91 | 0.91 | 0.91 | 0.87 | 0.87 | 0.87 |
| Available phosphorus (%) | 0.42 | 0.40 | 0.40 | 0.40 | 0.38 | 0.38 | 0.38 |
| Methionine (%) | 0.42 | 0.40 | 0.40 | 0.40 | 0.38 | 0.38 | 0.38 |
| Methionine + cystine (%) | 0.64 | 0.61 | 0.61 | 0.61 | 0.58 | 0.58 | 0.58 |
| Lysine (%) | 0.87 | 0.84 | 0.84 | 0.84 | 0.81 | 0.81 | 0.81 |

[1]C: Control (basal diet); T: Tallow; S: Soybean oil; P: Poultry oil. [2]Supplemented (For each kg of the diets): Vit. A, 12000 IU; D3, 2000 IU; E, 20 mg; K3, 3 mg; B2, 7 mg; B3, 12 mg; B5, 3 mg; B12, 0.03 mg; Biotin, 0.1 mg; Choline chloride, 300 mg and adequate anti oxidant. [3]Supplemented (For each kg of the diets): Mn, 130 mg; Fe, 70 mg; Zn, 60 mg; Cu,12 mg; I, 1 mg; Se, 0.2 mg

At 49 day of age, before slaughtering the final body weight and after that, weight of selected organs including liver, gizzard, heart, proventriculus, intestine and abdominal fat weight were recorded individually and presented as a percentage of live weight. The results obtained from the experiment were analyzed by an analysis of variance using the General Linear Model (GLM) procedure of SAS (2001) and means were compared by Duncan's Multiple Range test (Duncan, 1955).

## RESULTS AND DISCUSSION

### Performance Values

The effect of different types and levels of dietary fats that were added to control diet on performance values are presented in Table 3. The abdominal fat weight (percentage of live weight) in broilers that fed with 8% level of fats was found to be significantly ($p<0.05$) higher than broilers of control group. Whereas, the abdominal fat weight in broilers that consumed diets containing tallow or soybean oil in 4% level were no significantly higher than control group at 49 day of age.

### Visceral Organs Weight

The effect of different types and levels of dietary fats that were added to control diet on visceral organs weight are presented in Table 4. The liver weight (percentage of live weight) was significantly lower ($p<0.01$) in broilers that fed with diets containing 8% each one of fats and 4% of soybean oil at 49 day of age. Briefly, the weight of liver had showed decreasing by addition of fats to diet.

### Serum Lipids

The effect of dietary treatments on serum lipids were no significantly difference at 39 and 49 day of age (Table 5). Serum LDL concentration showed significant increasing from 35 to 49 day of age

Table 3: Means comparison of dietary treatments effect on performance values at 49 day of age

| Dietary treatments[1] | Total feed intake (g/bird) | Final body wight (g) | Feed conversion ratio (g $g^{-1}$) | Carcass efficiency (percentage of live weight) | Abdominal fat weight (percentage of live weight) |
|---|---|---|---|---|---|
| C (NRC) | 4210 | 1900 | 2.22 | 70.00 | 1.80$^{a}$ |
| C+4%T | 4210 | 1920 | 2.19 | 70.10 | 2.53$^{abc}$ |
| C+4%S | 4420 | 2000 | 2.24 | 69.50 | 2.23$^{ab}$ |
| C+4%P | 4460 | 2000 | 2.23 | 68.80 | 3.18$^{bc}$ |
| C+8%T | 4670 | 2170 | 2.15 | 69.60 | 2.95$^{bc}$ |
| C+8%S | 4410 | 2040 | 2.16 | 69.10 | 3.33$^{c}$ |
| C+8%P | 4230 | 1910 | 2.24 | 67.60 | 3.35$^{c}$ |

$^{a, b, c}$: Means within diets for each performance values with no common superscript differ significantly ($p<0.05$). [1]C: Control (basal diet); T: Tallow; S: Soybean oil; P: Poultry oil

Table 4: Means comparison of dietary treatment effect on visceral organs weight at 49 day of age

| Dietary treatments[1] | Liver | Gizzard | Heart | Proventriculus | Intestine |
|---|---|---|---|---|---|
| | (percentage of live weight) | | | | |
| C (NRC) | 1.76$^{ab}$ | 2.09 | 0.45 | 0.0039 | 0.042 |
| C+4%T | 1.70$^{ab}$ | 1.80 | 0.49 | 0.0037 | 0.038 |
| C+4%S | 1.61$^{bc}$ | 1.98 | 0.50 | 0.0030 | 0.046 |
| C+4%P | 1.80$^{a}$ | 1.98 | 0.46 | 0.0038 | 0.042 |
| C+8%T | 1.48$^{c}$ | 1.81 | 0.44 | 0.0038 | 0.042 |
| C+8%S | 1.59$^{c}$ | 1.92 | 0.50 | 0.0032 | 0.040 |
| C+8%P | 1.45$^{c}$ | 2.00 | 0.50 | 0.0041 | 0.049 |

$^{a, b, c}$: Means within diets for each visceral organs weight with no common superscript differ significantly ($p<0.01$). [1]C: Control (basal diet); T: Tallow; S: Soybean oil; P: Poultry oil

Table 5: Means comparison of dietary treatments effect on serum lipids at 39 and 49 day of age

| | Cholesterol | | Triglycerides | | HDL | | LDL | |
|---|---|---|---|---|---|---|---|---|
| Dietary treatments[1] | 35 day | 49 day | 35 day | 49 day | 35 day | 49 day | 35 day | 49 day |
| | (mg $dL^{-1}$) | | | | | | | |
| C (NRC) | 156.83±1.44 | 48.00±3.27 | 126.00±14.00 | 129.50±27.33 | 47.25±5.66 | 41.50±6.96 | 75.92±13.13 | 88.67±9.27 |
| C+4%T | 144.33±9.25 | 134.83±2.88 | 12.00±10.64 | 103.25±4.63 | 54.50±2.83 | 42.25±4.82 | 61.50±10.07 | 80.08±9.50 |
| C+4%S | 148.17±15.05 | 140.67±3.81 | 179.58±44.56 | 91.00±14.95 | 52.50±9.12 | 50.75±9.16 | 62.83±3.88 | 79.42±11.77 |
| C+4%P | 146.67±9.87 | 138.67±5.79 | 148.75±12.12 | 120.17±27.12 | 50.75±6.56 | 47.50±8.09 | 64.42±4.23 | 86.17±12.64 |
| C+8%T | 143.33±9.38 | 142.33±6.52 | 146.42±33.80 | 125.42±26.73 | 45.50±9.78 | 42.00±4.68 | 67.17±10.75 | 89.00±4.17 |
| C+8%S | 147.33±14.64 | 140.50±2.17 | 140.00±23.00 | 103.83±33.08 | 47.00±5.72 | 42.75±5.19 | 72.17±18.36 | 87.92±7.42 |
| C+8%P | 139.00±14.00 | 147.50±2.64 | 124.25±35.39 | 166.83±43.49 | 45.50±0.43 | 50.75±6.06 | 64.33±15.12 | 88.92±3.01 |

[1]C: Control (basal diet); T: Tallow; S: Soybean oil; P: Poultry oil

Table 6: Means comparison of serum lipids at 35 and 49 day of age

| Age (day) | Cholesterol | Triglycerids | HDL | LDL |
|---|---|---|---|---|
| | (mg $dL^{-1}$) | | | |
| 35 | 146.52±9.62$^{a}$ | 139.57±46.75$^{a}$ | 49.00±7.44 | 66.91±9.98$^{a}$ |
| 49 | 140.79±6.29$^{b}$ | 120.00±24.01$^{b}$ | 45.36±7.97 | 84.88±9.95$^{b}$ |

$^{a, b}$: Means within day of age for each serum lipids with no common superscript differ significantly ($p<0.05$)

($p<0.05$), whereas serum cholesterol and triglycerides concentrations showed decrease at same times ($p<0.05$) (Table 6). At 49 day of age increasing dietary fats level from 4 to 8%, serum cholesterol and triglycerides concentrations significantly were showed elevation ($p<0.05$), whereas serum HDL concentration had showed significantly decreasing by increasing of fats level at 35 day of age ($p<0.05$).

**Performance Values**

The observations obviously indicates with addition of fats to control diet that was balanced on NRC recommendations, the abdominal fat weight due to increasing of energy to protein ratio and stimulating of lipogenesis was significantly elevation ($p<0.01$). Bartov (1987) found that diets with a wide E: P ratio fed 1 or 2 to 7 weeks consistently and significantly increased abdominal fat pad size at 7 week of age. Keren *et al*. (1990) were reported that the relative weight of adipose tissue was higher in birds that fed high fat diet. But, Tabiedian *et al*. (2005) were reported that lowest abdominal fat in

groups of fed additional 0, 2.5, 5 and 7.5% soybean oil was observed in chicks that fed with a diet containing 7.5% soybean oil. Another performance values were no significant affected by additional dietary fats, but numerically due to increasing of diet palatability in broilers that fed with additional fat were better than broilers of control group. There was numerically, higher feed intake and final body weight and better feed conversation ratio in broilers that fed with 8% additional tallow fat. Sadeghi and Tabiedian (2005) were showed that adding of 5 and 7.5% tallow significantly ($p<0.05$) increasing feed intake due to better palatability of fat supplemented diet. These results showed that addition of fats to balanced diet and higher energy to protein ratio could meet all requirements for better growth rate.

**Visceral Organs Weight**

Addition of fats to control diet due to decreasing of liver lipogenesis activity, significantly ($p<0.01$) decreased liver weight (Table 4). Kirkpinar *et al*. (1999) were reported that liver weight effected by dietary fats ($p<0.01$). Tabiedian *et al*. (2005) reported that feeding different levels of soybean oil and tallow and protein had no effected on liver weight. Feeding with diets of containing additional fats had no effected on weight on gizzard, heart, proventriculus and intestine at 49 day of age (Table 4). This is agreement with results of Maiorka *et al*. (2005) and Sadeghi and Tabiedian (2005). Whereas, Kirkpinar *et al*. (1999) were reported that weight of liver, gizzard and heart were effected by dietary fats ($p<0.01$). Numerically, the weight of gizzard in broilers that fed with additional fat in diet, probably due to lubricating of diet by fat and lowering of gizzard activities had showed decreasing at final of experiment (49 day).

**Serum Lipids**

The effect of dietary treatment on serum lipids had no significant different (Table 5). Numerically, broiler chicken that receive additional fat have been found to have lower cholesterol concentration than birds fed control diet at 39 and 49 day of age. Resistance to high fat intake can also be increased by stimulation of cholesterol catabolism (Subbiah *et al*., 1983). Peebles *et al*. (1997) were reported that the 7% fat had a depressing effect on cholesterol in comparison to the 3% fat in diet. Alparslan and Ozdogan (2006) have confirmed that with addition of fish oil to diet, cholesterol values numerically had showed decrease in all groups. Because, cholesterol down-regulation the LDL receptor and inhibit the removal of LDL from serum by liver, the concentration of LDL similar to cholesterol concentration in control group numerically was higher than broilers that fed with additional fats in experimental diets. Therefore higher cholesterol, triglycerides and LDL concentration do not necessarily occur in broilers that fed with high-fat diet and they may be more efficient in clearing the added fat from their systems. This more resistance against the high dietary fat intake, may by due to an over-compensation may be related to the down-regulation of lipoprotein lipase. Concentrations of serum cholesterol and triglycerides significantly ($p<0.05$) and HDL numerically had showed decline from 35 to 49 day of age, but serum LDL concentration showed significant elevation at the same times ($p<0.05$) (Table 6). The relationship between cholesterol and HDL are largely related to the fact the HDL particles, rather than LDL, are the main cholesterol carriers in broiler chickens (Hermier and Dillon, 1992). These results are in agreement with previous studies (Castillo *et al*., 1992; Peebles *et al*., 1997). The results of Table 7 show that elevation of fats from 4 to 8% had no significant effect on serum cholesterol and

Table 7: Means comparison of additional fat levels effect on serum lipids at 39 and 49 day of age

| | Cholesterol | | Triglyceride | | HDL | | LDL | |
|---|---|---|---|---|---|---|---|---|
| Fat level (%) | 35 day | 49 day | 35 day | 49 day | 35 day | 49 day | 35 day | 49 day |
| | (mg $dL^{-1}$) | | | | | | | |
| 4 | 146.39±10.25 | 138.06±4.55[a] | 146.81±52.10 | 104.81±20.15[a] | 52.58±6.01[a] | 46.83±9.06 | 62.90±5.93 | 81.89±9.37 |
| 8 | 143.22±11.73 | 143.44±4.84[b] | 136.89±45.33 | 132.03±56.64[b] | 46.00±5.72[b] | 45.17±6.25 | 67.89±9.49 | 86.61±5.31 |

[a,b]: Means within additional fat percentage for each serum lipids with no common superscript differ significantly ($p<0.05$)

triglycerides at 35 day of age. But, at 49 day of age the body system of broilers do not resistance against the high fat level (8%) and serum cholesterol and triglycerides concentrations in broilers that fed with 8% additional fat significantly were higher than broilers fed with 4% additional fats ($p<0.05$). Peebles *et al*. (1997) had showed that the serum cholesterol was lower in broilers that fed 7% additional fat than is 0 and 3% additional fat at 35 day of age. Furthermore, they showed triglycerides concentration was also higher in birds that fed with diets containing of 3% additional fat compared to the 7% at 21 day of age.

It seems probable that the 8% level of fat due to existence of pathophysiologic state in broilers body systems, significantly cause decline serum HDL concentration at 35 day of age ($p<0.05$). But, this state probably due to adaptation of broilers system to high fat intake becomes dismissed at 49 day of age. With increasing of fat level from 4 to 8%, the serum LDL concentration numerically had showed elevation at 35 and 49 day of age. Griffin and Whitehead (1982) were reported that LDL concentration was only slightly higher in broilers fed on the high fat diet at 3 and 7 weeks of age.

## CONCLUSION

Broiler chickens probably because of some physiological resistance systems, like over-compensation (down-regulation of lipoprotein lipase) are more resistant against the high fat intake. Addition of 4% soybean oil or tallow to basal diet that was already balanced on NRC recommendations (increasing of energy and lowing of protein) is benefit for broilers performance, without significant increasing of abdominal fat weight, mortality and disorder in serum lipids. Certainly, with increasing of fat level from 4 to 8% and continuous from 35 to 49 day of age, health state in some serum lipids showed paucity disordering.

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