



Article

Physiological and Metabolic Effects of Yellow Mangosteen (*Garcinia dulcis*) Rind in Rats With Diet-Induced Metabolic Syndrome

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Supplementary File



Supplementary Table S1. Relative abundance of zOTUs affected by diet (ANOVA with *p* adjusted <0.05) between C, CGD, H and HGD rats.

| OTU_ID | C (%) | CGD (%) | H (%) | HGD (%) | Phylum | Family | Genus |
|----------|-------|---------|-------|---------|----------------|-----------------------|--|
| Zotu24 | 0.89 | 1.43 | 0.04 | 0.02 | Actinobacteria | Bifidobacteriaceae | <i>Bifidobacterium</i> |
| Zotu19 | 0.00 | 0.00 | 0.11 | 2.53 | Firmicutes | Lachnospiraceae | [<i>Bacteroides</i>] pectinophilus group |
| Zotu228 | 0.17 | 0.15 | 0.00 | 0.00 | Firmicutes | Lachnospiraceae | <i>Acetitomaculum</i> |
| Zotu131 | 0.05 | 0.05 | 0.36 | 0.25 | Firmicutes | Lachnospiraceae | <i>Anaerostipes</i> |
| Zotu153 | 0.11 | 0.38 | 0.00 | 0.01 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group |
| Zotu1122 | 0.00 | 0.00 | 0.02 | 0.02 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group |
| Zotu118 | 0.00 | 0.01 | 0.81 | 0.11 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> UCG-006 |
| Zotu714 | 0.00 | 0.00 | 0.04 | 0.03 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> UCG-008 |
| Zotu162 | 0.00 | 0.01 | 0.26 | 0.23 | Firmicutes | Lachnospiraceae | <i>Roseburia</i> |
| Zotu53 | 0.04 | 0.01 | 0.92 | 0.41 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu544 | 0.00 | 0.00 | 0.07 | 0.03 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu671 | 0.00 | 0.00 | 0.02 | 0.02 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu231 | 0.00 | 0.00 | 0.11 | 0.10 | Firmicutes | Peptococcaceae | unclassified |
| Zotu70 | 0.02 | 0.06 | 0.62 | 0.15 | Firmicutes | Peptostreptococcaceae | unclassified |
| Zotu166 | 0.12 | 0.17 | 0.00 | 0.00 | Firmicutes | Ruminococcaceae | [<i>Eubacterium</i>] coprostanoligenes group |
| Zotu194 | 0.00 | 0.00 | 0.19 | 0.07 | Firmicutes | Ruminococcaceae | <i>Ruminiclostridium</i> 9 |
| Zotu272 | 0.01 | 0.01 | 0.05 | 0.09 | Firmicutes | Ruminococcaceae | <i>Ruminiclostridium</i> 9 |
| Zotu276 | 0.01 | 0.00 | 0.13 | 0.06 | Firmicutes | Ruminococcaceae | <i>Ruminiclostridium</i> 9 |
| Zotu236 | 0.00 | 0.00 | 0.18 | 0.06 | Firmicutes | Ruminococcaceae | unclassified |

Differential abundance analysis was performed using Mvabund. C, corn starch diet-fed rats; CGD, corn starch diet-fed rats treated with *Garcinia dulcis* rind powder; H, high-carbohydrate, high-fat diet-fed rats; HGD, high-carbohydrate, high-fat diet-fed rats treated with *Garcinia dulcis* rind powder.

Supplementary Table S2. Relative abundance of zOTUs affected by treatment (ANOVA with *p* adjusted <0.05) between C, CGD, H and HGD rats.

| OTU_ID | C (%) | CGD (%) | H (%) | HGD (%) | Phylum | Family | Genus |
|----------|-------|---------|-------|---------|---------------|------------------|--------------------------------------|
| Zotu28 | 0.09 | 0.78 | 0.06 | 0.75 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> |
| Zotu46 | 0.08 | 0.86 | 0.02 | 0.36 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> |
| Zotu211 | 0.01 | 0.17 | 0.01 | 0.07 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> |
| Zotu343 | 0.00 | 0.07 | 0.00 | 0.03 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> |
| Zotu477 | 0.00 | 0.06 | 0.00 | 0.01 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> |
| Zotu604 | 0.00 | 0.01 | 0.00 | 0.02 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> |
| Zotu3 | 9.24 | 0.07 | 13.31 | 1.19 | Firmicutes | Clostridiaceae 1 | <i>Clostridium sensu stricto 1</i> |
| Zotu1064 | 0.54 | 0.10 | 0.89 | 0.11 | Firmicutes | Clostridiaceae 1 | <i>Clostridium sensu stricto 1</i> |
| Zotu410 | 0.03 | 0.00 | 0.11 | 0.00 | Firmicutes | Lachnospiraceae | <i>Acetitomaculum</i> |
| Zotu372 | 0.01 | 0.00 | 0.12 | 0.01 | Firmicutes | Lachnospiraceae | <i>Blautia</i> |
| Zotu156 | 0.00 | 0.00 | 0.72 | 0.00 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group |
| Zotu232 | 0.29 | 0.00 | 0.06 | 0.00 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group |
| Zotu239 | 0.09 | 0.00 | 0.29 | 0.00 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group |
| Zotu400 | 0.01 | 0.00 | 0.19 | 0.00 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group |
| Zotu447 | 0.09 | 0.00 | 0.12 | 0.00 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu469 | 0.00 | 0.05 | 0.01 | 0.04 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu473 | 0.00 | 0.03 | 0.00 | 0.06 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu487 | 0.00 | 0.03 | 0.00 | 0.05 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu658 | 0.00 | 0.02 | 0.00 | 0.03 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu124 | 0.13 | 0.00 | 0.38 | 0.00 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu173 | 0.03 | 0.00 | 0.47 | 0.00 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu174 | 0.03 | 0.00 | 0.43 | 0.01 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu184 | 0.00 | 0.21 | 0.00 | 0.11 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu304 | 0.01 | 0.08 | 0.02 | 0.10 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu415 | 0.03 | 0.01 | 0.11 | 0.00 | Firmicutes | Lachnospiraceae | unclassified |
| Zotu555 | 0.02 | 0.00 | 0.04 | 0.00 | Firmicutes | Ruminococcaceae | <i>Pygmaibacter</i> |
| Zotu392 | 0.03 | 0.00 | 0.06 | 0.02 | Firmicutes | Ruminococcaceae | <i>Ruminococcaceae</i> UCG-010 |
| Zotu155 | 0.36 | 0.00 | 0.03 | 0.00 | Firmicutes | Ruminococcaceae | <i>Ruminococcaceae</i> UCG-014 |

| | | | | | | | |
|----------|------|------|------|------|-----------------|--------------------|---------------------------------|
| Zotu328 | 0.13 | 0.00 | 0.03 | 0.00 | Firmicutes | Ruminococcaceae | <i>Ruminococcaceae</i> UCG-014 |
| Zotu1018 | 0.01 | 0.00 | 0.04 | 0.00 | Firmicutes | Ruminococcaceae | <i>Ruminococcaceae</i> UCG-014 |
| Zotu662 | 0.05 | 0.00 | 0.03 | 0.00 | Firmicutes | Ruminococcaceae | UBA1819 |
| Zotu412 | 0.02 | 0.00 | 0.10 | 0.00 | Firmicutes | Ruminococcaceae | unclassified |
| Zotu249 | 0.07 | 0.00 | 0.13 | 0.00 | Patescibacteria | Saccharimonadaceae | <i>Candidatus Saccharimonas</i> |
| Zotu21 | 0.12 | 1.66 | 0.01 | 0.34 | Proteobacteria | Burkholderiaceae | <i>Parasutterella</i> |
| Zotu230 | 0.01 | 0.16 | 0.00 | 0.02 | Proteobacteria | Burkholderiaceae | <i>Parasutterella</i> |

Differential abundance analysis was performed using Mvabund. C, corn starch diet-fed rats; CGD, corn starch diet-fed rats treated with *Garcinia dulcis* rind powder; H, high-carbohydrate, high-fat diet-fed rats; HGD, high-carbohydrate, high-fat diet-fed rats treated with *Garcinia dulcis* rind powder.



Supplementary Table S3. PERMANOVAs based on Euclidean distance matrix for square-root transformed physiological data of all rat faecal samples.

| Source | df | SS | MS | Pseudo-F | P(perm) | Unique perms |
|-----------|----|---------|---------|----------|---------|--------------|
| Diet | 1 | 508800 | 508800 | 15.819 | 0.0002 | 9944 |
| Treatment | 1 | 1680200 | 1680200 | 52.238 | 0.0001 | 9929 |
| Diet × | 1 | 80304 | 80304 | 2.4967 | 0.066 | 9941 |
| Res | 18 | 578960 | 578960 | | | |
| Total | 21 | 2829600 | | | | |

PAIR-WISE TESTS

| Groups | <i>t</i> | <i>p</i> (perm) | Unique perms |
|----------|----------|-----------------|--------------|
| C, CGD | 5.3183 | 0.0015 | 462 |
| C, H | 2.882 | 0.0083 | 126 |
| C, HGD | 3.0829 | 0.0022 | 462 |
| CGD, H | 7.593 | 0.0022 | 462 |
| CGD, HGD | 2.9817 | 0.0046 | 462 |
| H, HGD | 5.1842 | 0.0023 | 462 |

PERMDISP (PAIRWISE COMPARISONS)

| Groups | <i>t</i> | <i>p</i> (perm) |
|----------|----------|-----------------|
| C, CGD | 2.4667 | 0.034 |
| C, H | 1.2354 | 0.2938 |
| C, HGD | 0.4574 | 0.6399 |
| CGD, H | 3.7652 | 0.0028 |
| CGD, HGD | 1.6279 | 0.2023 |
| H, HGD | 1.6442 | 0.151 |

p values were calculated using 9,999 permutations under a residual model. C, corn starch diet-fed rats; CGD, corn starch diet-fed rats treated with *Garcinia dulcis* rind powder; H, high-carbohydrate, high-fat diet-fed rats; HGD, high-carbohydrate, high-fat diet-fed rats treated with *Garcinia dulcis* rind powder.

Supplementary Table S4. Correlation between bacterial community structure and physiological parameters

| Physiological Variables | R ² | <i>p</i> value |
|---|----------------|----------------|
| Feed efficiency | 0.78 | 0.001 |
| Body weight | 0.75 | 0.001 |
| Left ventricle and septum weight | 0.66 | 0.002 |
| Omental fat | 0.64 | 0.001 |
| Water intake | 0.64 | 0.002 |
| Total abdominal fat | 0.59 | 0.001 |
| Plasma non-esterified fatty acids | 0.58 | 0.001 |
| Retroperitoneal fat | 0.57 | 0.001 |
| Liver wet weight | 0.57 | 0.004 |
| Plasma triglycerides | 0.57 | 0.002 |
| Fat mass | 0.57 | 0.001 |
| Kidneys wet weight | 0.52 | 0.004 |
| Oral glucose tolerance area under the curve | 0.40 | 0.012 |
| Epididymal fat | 0.38 | 0.015 |
| Energy intake | 0.36 | 0.020 |
| Systolic blood pressure | 0.35 | 0.026 |
| Food intake | 0.32 | 0.033 |



Supplementary Table 5. Taxonomic assignments of the OTUs strongly correlated with physiological parameters.

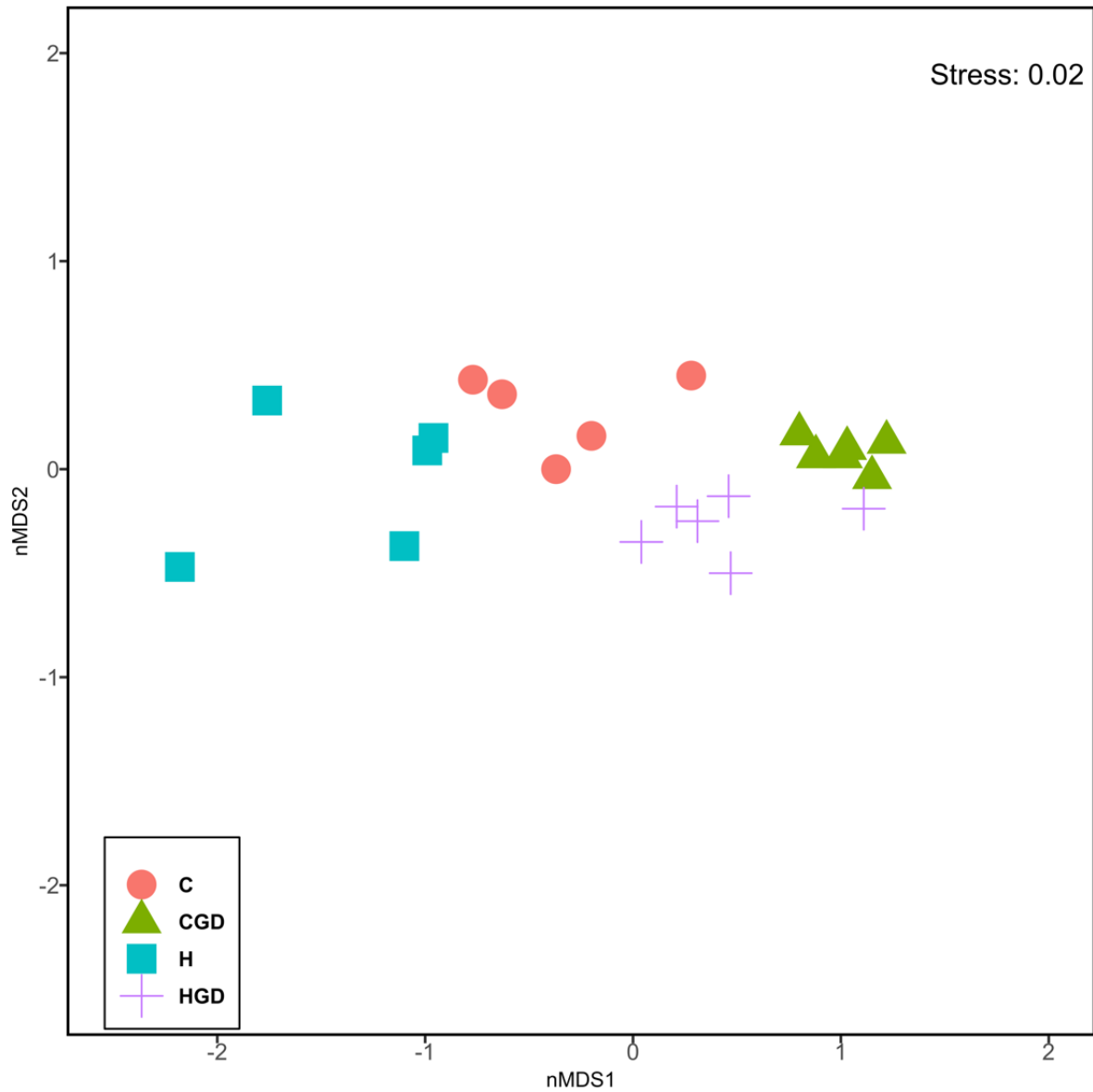
| OTU_ID | Phylum | Family | Genus | Correlation with physiological parameters |
|----------|----------------|--------------------|--------------------------------------|---|
| Zotu24 | Actinobacteria | Bifidobacteriaceae | <i>Bifidobacterium</i> | Body weight (+), epididymal fat (+), fat mass (+), feed efficiency (+), Plasma non-esterified fatty |
| Zotu477 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> | Kidney wet weight (+), Plasma non-esterified fatty acids (+), oral glucose tolerance area under the |
| Zotu343 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> | Kidney wet weight (+), liver wet weight (+) |
| Zotu46 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> | Kidney wet weight (+), liver wet weight (+) |
| Zotu211 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> | Kidney wet weight (+) |
| Zotu28 | Bacteroidetes | Tannerellaceae | <i>Parabacteroides</i> | Liver wet weight (+) |
| Zotu1064 | Firmicutes | Clostridiaceae 1 | <i>Clostridium sensu stricto 1</i> | Kidney wet weight (-), liver wet weight (-),(+), oral glucose tolerance area under the curve (-), |
| Zotu3 | Firmicutes | Clostridiaceae 1 | <i>Clostridium sensu stricto 1</i> | Liver wet weight (-), oral glucose tolerance area under the curve (-) |
| Zotu410 | Firmicutes | Lachnospiraceae | <i>Acetitomaculum</i> | Kidney wet weight (-), liver wet weight (-), plasma triglycerides (-) |
| Zotu228 | Firmicutes | Lachnospiraceae | <i>Acetitomaculum</i> | Left ventricle and septum wet weight (+), omental fat (+) |
| Zotu131 | Firmicutes | Lachnospiraceae | <i>Anaerostipes</i> | Body weight (-), epididymal fat (-), fat mass (-), feed efficiency (-), left ventricle and septum wet |
| Zotu372 | Firmicutes | Lachnospiraceae | <i>Blautia</i> | Kidney wet weight (-) |
| Zotu247 | Firmicutes | Lachnospiraceae | <i>Coprococcus 2</i> | Energy intake (-), kidney wet weight (-) |
| Zotu1122 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group | Body weight (-), epididymal fat (-), fat mass (-), feed efficiency (-), left ventricle and septum wet |
| Zotu153 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group | Plasma non-esterified fatty acids (+), oral glucose tolerance area under the curve (+), omental fat (+), |
| Zotu400 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group | Energy intake (-), food intake (-), kidney wet weight (-) |
| Zotu156 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> NK4A136 group | Food intake (-), kidney wet weight (-) |
| Zotu118 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> UCG-006 | Energy intake (-), fat mass (-), feed efficiency (-) |
| Zotu714 | Firmicutes | Lachnospiraceae | <i>Lachnospiraceae</i> UCG-008 | Body weight (-), fat mass (-), feed efficiency(-), left ventricle & septum wet weight (-) |
| Zotu162 | Firmicutes | Lachnospiraceae | <i>Roseburia</i> | Body weight (-), fat mass (-), feed efficiency (-), plasma non-esterified fatty acids (-), omental fat (-), |
| Zotu544 | Firmicutes | Lachnospiraceae | unclassified | Body weight (-), energy intake (-), fat mass (-), food intake (-), feed efficiency (-), left ventricle and |
| Zotu184 | Firmicutes | Lachnospiraceae | unclassified | Food intake (+), kidney wet weight (+), liver wet weight (+), plasma non-esterified fatty acids (+), oral |
| Zotu671 | Firmicutes | Lachnospiraceae | unclassified | Body weight (-), fat mass (-), feed efficiency (-), left ventricle and septum wet weight (-), water |
| Zotu53 | Firmicutes | Lachnospiraceae | unclassified | Body weight (-), energy intake (-), fat mass (-), feed efficiency (-) |
| Zotu415 | Firmicutes | Lachnospiraceae | unclassified | Kidney wet weight (-), liver wet weight (-), systolic blood pressure (-) |
| Zotu304 | Firmicutes | Lachnospiraceae | unclassified | Liver wet weight (+), oral glucose tolerance area under the curve (+) |
| Zotu469 | Firmicutes | Lachnospiraceae | unclassified | Liver wet weight (+), oral glucose tolerance area under the curve (+) |
| Zotu173 | Firmicutes | Lachnospiraceae | unclassified | Kidney wet weight (-) |

| | | | | |
|----------|----------------|-----------------------|--|--|
| Zotu174 | Firmicutes | Lachnospiraceae | unclassified | Kidney wet weight (-) |
| Zotu473 | Firmicutes | Lachnospiraceae | unclassified | Liver wet weight (+) |
| Zotu658 | Firmicutes | Lachnospiraceae | unclassified | Liver wet weight (+) |
| Zotu70 | Firmicutes | Peptostreptococcaceae | unclassified | Energy intake (-), fat mass (-), feed efficiency (-), food efficiency (-), omental fat (-) |
| Zotu166 | Firmicutes | Ruminococcaceae | [<i>Eubacterium</i>] coprostanoligenes group | Body weight (+), fat mass (+) |
| Zotu555 | Firmicutes | Ruminococcaceae | <i>Pygmaio bacter</i> | Kidney wet weight (-), plasma triglycerides (-) |
| Zotu276 | Firmicutes | Ruminococcaceae | <i>Ruminclostridium 9</i> | Body weight (-), fat mass (-), omental fat (-), total abdominal fat (-) |
| Zotu392 | Firmicutes | Ruminococcaceae | <i>Ruminococcaceae</i> UCG-010 | Kidney wet weight (-), plasma triglycerides (-) |
| Zotu1018 | Firmicutes | Ruminococcaceae | <i>Ruminococcaceae</i> UCG-014 | Energy intake (-), fat mass (-), food intake (-) |
| Zotu412 | Firmicutes | Ruminococcaceae | unclassified | Kidney wet weight (-) |
| Zotu21 | Proteobacteria | Burkholderiaceae | <i>Parasutterella</i> | Plasma non-esterified fatty acids (+), plasma triglycerides (+) |
| Zotu230 | Proteobacteria | Burkholderiaceae | <i>Parasutterella</i> | Plasma non-esterified fatty acids (+), plasma triglycerides (+) |

This table includes the physiological parameters strongly correlated ($p < 0.05$) with the bacterial community and incorporates OTUs that interact with at least 3 of these parameters. Plus sign (+) indicates positive correlations, while minus sign (-) indicates negative correlations.

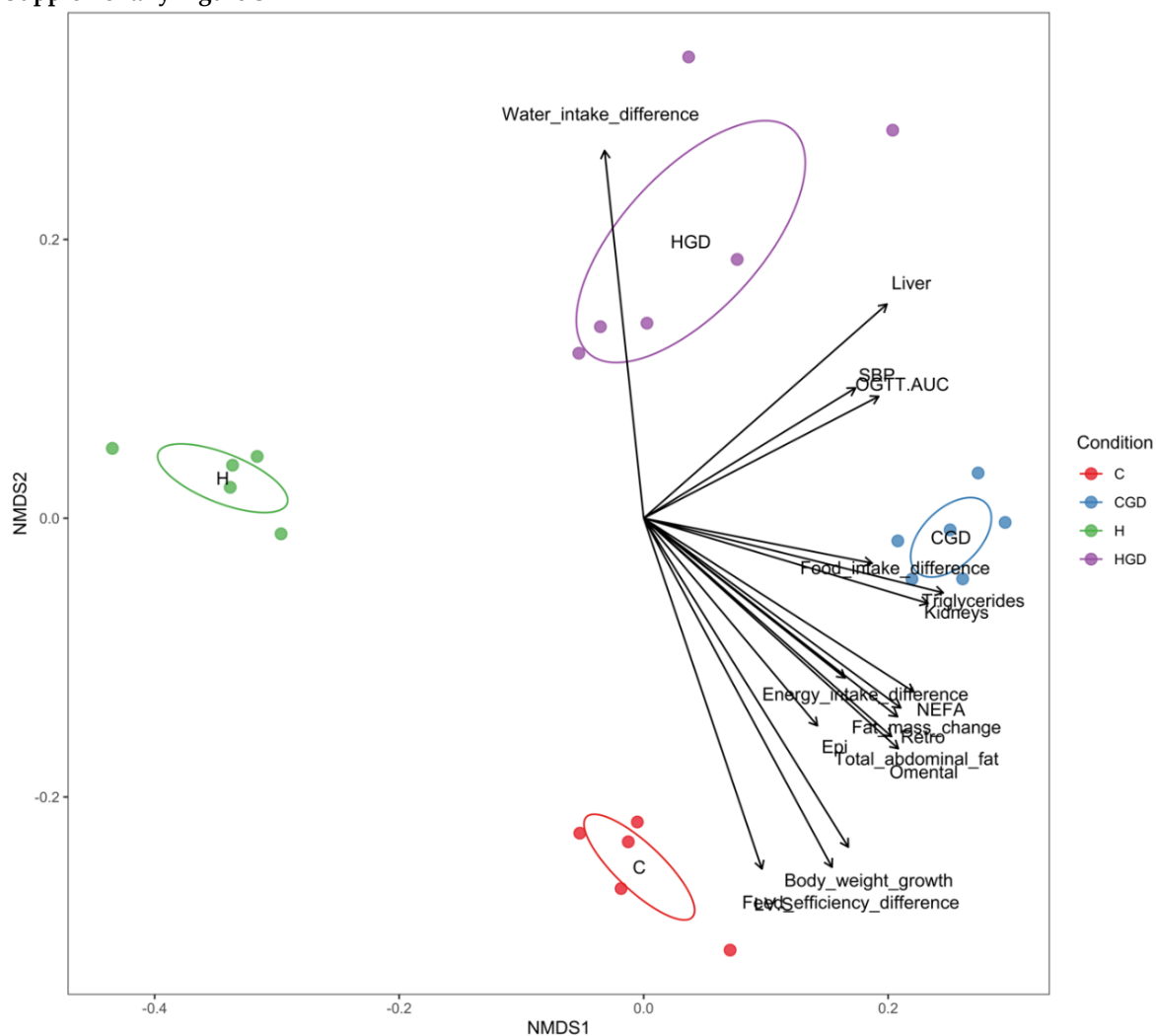


Supplementary Figure S1



Supplementary Figure S1. nMDS plot of physiological data from 23 physiological parameters. C, corn starch diet-fed rats; CGD, corn starch diet-fed rats treated with *Garcinia dulcis* rind powder; H, high-carbohydrate, high-fat diet-fed rats; HGD, high-carbohydrate, high-fat diet-fed rats treated with *Garcinia dulcis* rind powder.

Supplementary Figure S2



Supplementary Figure S2. Correlation between bacterial community structure (points) and environmental variables (arrows). C, corn starch diet-fed rats; CGD, corn starch diet-fed rats treated with *Garcinia dulcis* rind powder; H, high-carbohydrate, high-fat diet-fed rats; HGD, high-carbohydrate, high-fat diet-fed rats treated with *Garcinia dulcis* rind powder.



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