

**S7 Table. RDP classification of the sequence reads at class level.** Data are presented as the means  $\pm$  S.D and analyzed by Mann-Whitney test, \*\*\* $P$ <0.001, \*\* $P$ <0.01 and \* $P$ <0.05 vs the HFD group.

| Class                        | Control (%)                       | HFD (%)          | HFD+M (%)                         | HFD+FO600 (%)                    | HFD+KO600 (%)                     | HFD+FO300KO300 (%)               | HFD+FO400KO200 (%)                | HFD+FO450KO150 (%)             |
|------------------------------|-----------------------------------|------------------|-----------------------------------|----------------------------------|-----------------------------------|----------------------------------|-----------------------------------|--------------------------------|
| <i>Bacteroidia</i>           | 68.38 $\pm$ 6.41 $\uparrow$ ***   | 33.77 $\pm$ 4.88 | 43.16 $\pm$ 8.74 $\uparrow$ *     | 53.9 $\pm$ 10.37 $\uparrow$ **   | 43.73 $\pm$ 6.89 $\uparrow$ **    | 34.53 $\pm$ 6.88 $\uparrow$      | 39.78 $\pm$ 8.89 $\uparrow$       | 32.75 $\pm$ 5.67 $\downarrow$  |
| <i>Clostridia</i>            | 16.46 $\pm$ 3.16 $\downarrow$ *** | 38.63 $\pm$ 6.74 | 19.91 $\pm$ 4.32 $\downarrow$ *** | 35.14 $\pm$ 7.62 $\downarrow$    | 21.29 $\pm$ 3.41 $\downarrow$ *** | 38.34 $\pm$ 5.96 $\downarrow$    | 36.34 $\pm$ 7.42 $\downarrow$     | 35.4 $\pm$ 5.87 $\downarrow$   |
| <i>Deltaproteobacteria</i>   | 1.57 $\pm$ 0.38 $\downarrow$ ***  | 11.95 $\pm$ 2.65 | 5.67 $\pm$ 1.32 $\downarrow$ **   | 1.35 $\pm$ 0.23 $\downarrow$ *** | 6.01 $\pm$ 2.46 $\downarrow$ **   | 20.73 $\pm$ 4.67 $\uparrow$ **   | 3.26 $\pm$ 2.34 $\downarrow$ ***  | 9.74 $\pm$ 4.67 $\downarrow$   |
| <i>Bacilli</i>               | 1.17 $\pm$ 0.24 $\downarrow$ **   | 6.42 $\pm$ 1.17  | 8.63 $\pm$ 2.13 $\uparrow$        | 2.38 $\pm$ 0.34 $\downarrow$ *** | 10.57 $\pm$ 3.11 $\uparrow$ *     | 0.69 $\pm$ 0.12 $\downarrow$ *** | 6.23 $\pm$ 1.47 $\downarrow$      | 4.57 $\pm$ 1.37 $\downarrow$   |
| <i>Erysipelotrichia</i>      | 6.45 $\pm$ 1.13 $\uparrow$ **     | 1.81 $\pm$ 0.44  | 11.13 $\pm$ 2.24 $\uparrow$ ***   | 1.01 $\pm$ 0.18 $\downarrow$     | 4.44 $\pm$ 1.56 $\uparrow$ **     | 1.71 $\pm$ 0.22 $\downarrow$     | 4.65 $\pm$ 1.33 $\uparrow$ **     | 4.56 $\pm$ 1.42 $\uparrow$ **  |
| <i>Epsilonproteobacteria</i> | 1.69 $\pm$ 0.32 $\downarrow$ *    | 2.59 $\pm$ 0.32  | 2.8 $\pm$ 0.43 $\uparrow$         | 2.21 $\pm$ 0.28 $\downarrow$     | 2.15 $\pm$ 0.98 $\downarrow$      | 1.19 $\pm$ 0.07 $\downarrow$ *   | 0.87 $\pm$ 0.16 $\downarrow$ ***  | 7.06 $\pm$ 2.17 $\uparrow$ *** |
| <i>Actinobacteria</i>        | 2.17 $\pm$ 0.47 $\uparrow$ *      | 1.74 $\pm$ 0.27  | 4.29 $\pm$ 0.26 $\uparrow$        | 1.25 $\pm$ 0.16 $\downarrow$     | 5.1 $\pm$ 1.17 $\uparrow$ **      | 0.79 $\pm$ 0.04 $\downarrow$ *   | 3.65 $\pm$ 0.78 $\uparrow$ ***    | 2.32 $\pm$ 0.43 $\uparrow$ **  |
| <i>Gammaproteobacteria</i>   | 0.52 $\pm$ 0.11 $\uparrow$        | 0.47 $\pm$ 0.13  | 2.06 $\pm$ 0.17 $\uparrow$ **     | 0.48 $\pm$ 0.24 $\uparrow$       | 1.36 $\pm$ 0.05 $\uparrow$ ***    | 0.56 $\pm$ 0.26 $\uparrow$ ***   | 0.96 $\pm$ 0.22 $\uparrow$ ***    | 0.9 $\pm$ 0.26 $\uparrow$ ***  |
| <i>Betaproteobacteria</i>    | 0.8 $\pm$ 0.16 $\uparrow$         | 0.59 $\pm$ 0.24  | 0.77 $\pm$ 0.06 $\uparrow$        | 0.43 $\pm$ 0.17 $\downarrow$     | 1.5 $\pm$ 0.17 $\uparrow$ **      | 0.21 $\pm$ 0.01 $\downarrow$ *** | 1.2 $\pm$ 0.32 $\uparrow$ ***     | 0.7 $\pm$ 0.12 $\uparrow$ **   |
| <i>Alphaproteobacteria</i>   | 0.18 $\pm$ 0.03 $\downarrow$      | 0.28 $\pm$ 0.04  | 0.25 $\pm$ 0.05 $\downarrow$      | 0.21 $\pm$ 0.09 $\downarrow$     | 0.84 $\pm$ 0.11 $\uparrow$ *      | 0.13 $\pm$ 0.04 $\downarrow$ *   | 0.59 $\pm$ 0.18 $\uparrow$ ***    | 0.36 $\pm$ 0.11 $\uparrow$ **  |
| <i>Chloroplast</i>           | 0.11 $\pm$ 0.04 $\downarrow$ *    | 0.21 $\pm$ 0.05  | 0.26 $\pm$ 0.11 $\uparrow$        | 0.16 $\pm$ 0.05 $\downarrow$     | 0.79 $\pm$ 0.23 $\uparrow$ **     | 0.07 $\pm$ 0.01 $\downarrow$ **  | 0.73 $\pm$ 0.25 $\uparrow$ ***    | 0.36 $\pm$ 0.14 $\uparrow$     |
| <i>Unclassified</i>          | 0.15 $\pm$ 0.01 $\downarrow$ *    | 0.59 $\pm$ 0.03  | 0.25 $\pm$ 0.03 $\downarrow$      | 0.5 $\pm$ 0.07 $\downarrow$      | 0.17 $\pm$ 0.06 $\downarrow$ *    | 0.38 $\pm$ 0.02 $\downarrow$     | 0.25 $\pm$ 0.11 $\downarrow$      | 0.2 $\pm$ 0.07 $\downarrow$ ** |
| <i>Planctomycetia</i>        | 0.09 $\pm$ 0.01 $\downarrow$ *    | 0.18 $\pm$ 0.07  | 0.29 $\pm$ 0.09 $\uparrow$        | 0.14 $\pm$ 0.03 $\downarrow$     | 0.59 $\pm$ 0.08 $\uparrow$ **     | 0.06 $\pm$ 0.01 $\downarrow$ *   | 0.47 $\pm$ 0.14 $\uparrow$ ***    | 0.2 $\pm$ 0.09 $\uparrow$ **   |
| <i>Deferribacteres</i>       | 0.01 $\pm$ 0.002 $\downarrow$ **  | 0.28 $\pm$ 0.03  | 0.05 $\pm$ 0.001 $\downarrow$ *   | 0.61 $\pm$ 0.17 $\uparrow$ **    | 0.18 $\pm$ 0.04 $\downarrow$      | 0.45 $\pm$ 0.02 $\uparrow$ ***   | 0.02 $\pm$ 0.005 $\downarrow$ *** | 0.41 $\pm$ 0.03 $\uparrow$ *** |
| <i>Cyanobacteria</i>         | 0.04 $\pm$ 0.013 $\downarrow$     | 0.09 $\pm$ 0.01  | 0.1 $\pm$ 0.01 $\uparrow$         | 0.05 $\pm$ 0.01 $\downarrow$     | 0.31 $\pm$ 0.13 $\uparrow$ **     | 0.03 $\pm$ 0.006 $\downarrow$    | 0.25 $\pm$ 0.02 $\uparrow$        | 0.11 $\pm$ 0.04 $\uparrow$     |
| <i>Spartobacteria</i>        | 0.03 $\pm$ 0.005 $\downarrow$     | 0.07 $\pm$ 0.01  | 0.07 $\pm$ 0.01                   | 0.04 $\pm$ 0.003 $\downarrow$    | 0.21 $\pm$ 0.09 $\uparrow$        | 0.02 $\pm$ 0.003 $\downarrow$    | 0.13 $\pm$ 0.04 $\uparrow$        | 0.07 $\pm$ 0.01 $\downarrow$   |
| <i>Sphingobacteriia</i>      | 0.02 $\pm$ 0.002 $\downarrow$     | 0.04 $\pm$ 0.001 | 0.09 $\pm$ 0.02 $\uparrow$        | 0.03 $\pm$ 0.005 $\downarrow$    | 0.18 $\pm$ 0.04 $\uparrow$ *      | 0.02 $\pm$ 0.004 $\downarrow$ *  | 0.15 $\pm$ 0.03 $\uparrow$ ***    | 0.07 $\pm$ 0.02 $\uparrow$ **  |
| <i>Flavobacteriia</i>        | 0.03 $\pm$ 0.004 $\downarrow$     | 0.06 $\pm$ 0.002 | 0.03 $\pm$ 0.001 $\downarrow$     | 0.03 $\pm$ 0.001 $\downarrow$    | 0.13 $\pm$ 0.01 $\uparrow$ **     | 0.03 $\pm$ 0.004 $\downarrow$ *  | 0.09 $\pm$ 0.01 $\uparrow$ *      | 0.03 $\pm$ 0.006*              |
| <i>Phycisphaerae</i>         | 0.03 $\pm$ 0.005 $\downarrow$     | 0.04 $\pm$ 0.001 | 0.04 $\pm$ 0.002                  | 0.02 $\pm$ 0.001 $\downarrow$    | 0.09 $\pm$ 0.02 $\uparrow$        | 0.02 $\pm$ 0.002 $\downarrow$    | 0.08 $\pm$ 0.02 $\uparrow$        | 0.02 $\pm$ 0.002 $\downarrow$  |
| <i>Opitutae</i>              | 0.02 $\pm$ 0.003 $\downarrow$     | 0.03 $\pm$ 0.003 | 0.02 $\pm$ 0.001 $\downarrow$     | 0.01 $\pm$ 0.001 $\downarrow$    | 0.07 $\pm$ 0.01 $\uparrow$        | 0.04 $\pm$ 0.006 $\downarrow$    | 0.09 $\pm$ 0.01 $\uparrow$        | 0.03 $\pm$ 0.004 $\uparrow$    |