The average power follows similarly:

$$\begin{aligned}
\lim_{N\to\infty} \frac{1}{N} \sum_{n=0}^{N-1} |x[n]|^2 &= \lim_{N\to\infty} \frac{1}{N} \sum_{n=0}^{N-1} \left(\sum_{\ell=0}^{K} a_\ell e^{j2\pi k\ell f_0 n} \right) \left(\sum_{k=0}^{K} a_k e^{j2\pi k f_0 n} \right)^* \\
&= \lim_{N\to\infty} \sum_{\ell=0}^{K} \sum_{k=0}^{K} a_\ell a_k^* \left(\frac{1}{N} \sum_{n=0}^{N-1} e^{j2\pi k\ell f_0 n} e^{-j2\pi k f_0 n} \right) \\
&= \lim_{N\to\infty} \sum_{\ell=0}^{K} \sum_{k=0}^{K} a_\ell a_k^* \left(\frac{1}{N} \sum_{n=0}^{N-1} e^{j2\pi k(\ell-k) f_0 n} \right) \\
&= \lim_{N\to\infty} \sum_{k=0}^{K} |a_k|^2
\end{aligned}$$