1. DATA AND PRE-PROCESSING

Original Image : https://bit.ly/3jcyxcS

The image was downloaded as a PNG file.

- `Scikit-image` was used to read in the image
- The original image dimensions were 2700 x 3573
- The original image size was 8.9 MB
- Since `OpenCV` uses the BGR (blue, green, red) format, the image was converted from RGB to BGR

2. MODELS

k-Means Clustering:

- K-Means clustering was done using `OpenCV`
- Random centers were taken as the initial centers
- The number of attempts was set to 10
- The iteration termination criteria was set to either 100 iterations or an accuracy of 0.2, whichever was reached first

Principal Component Analysis:

- PCA was done using `sklearn`
- Apart from the number of components, all other parameters were set to their default values

3. EXPERIMENT LOG

k-Means Clustering:

k = 2

Figure 1: Compressed Image (left) vs. Original Image (right)

k = 4

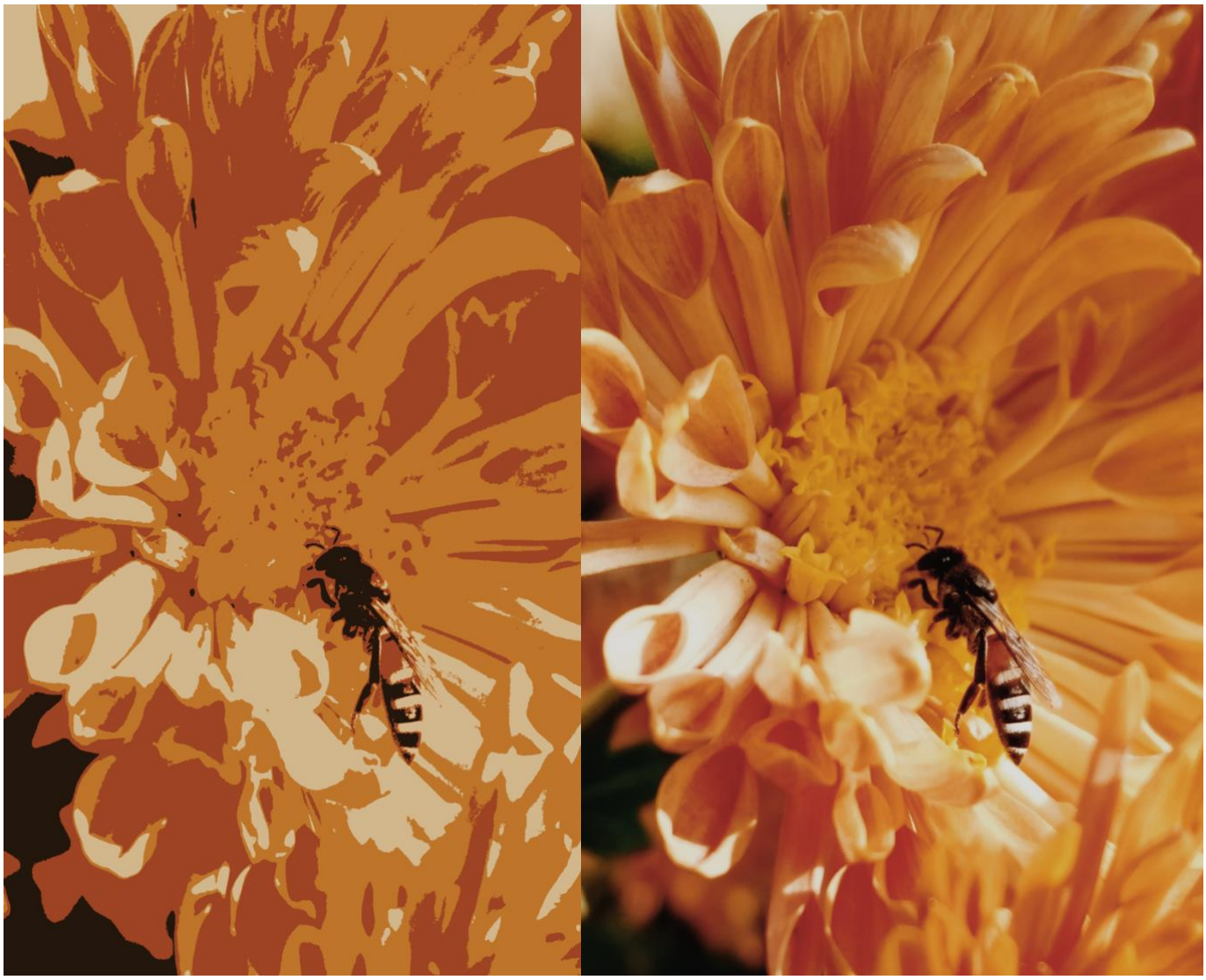

Figure 2: Compressed Image (left) vs. Original Image (right)

$k = 6$

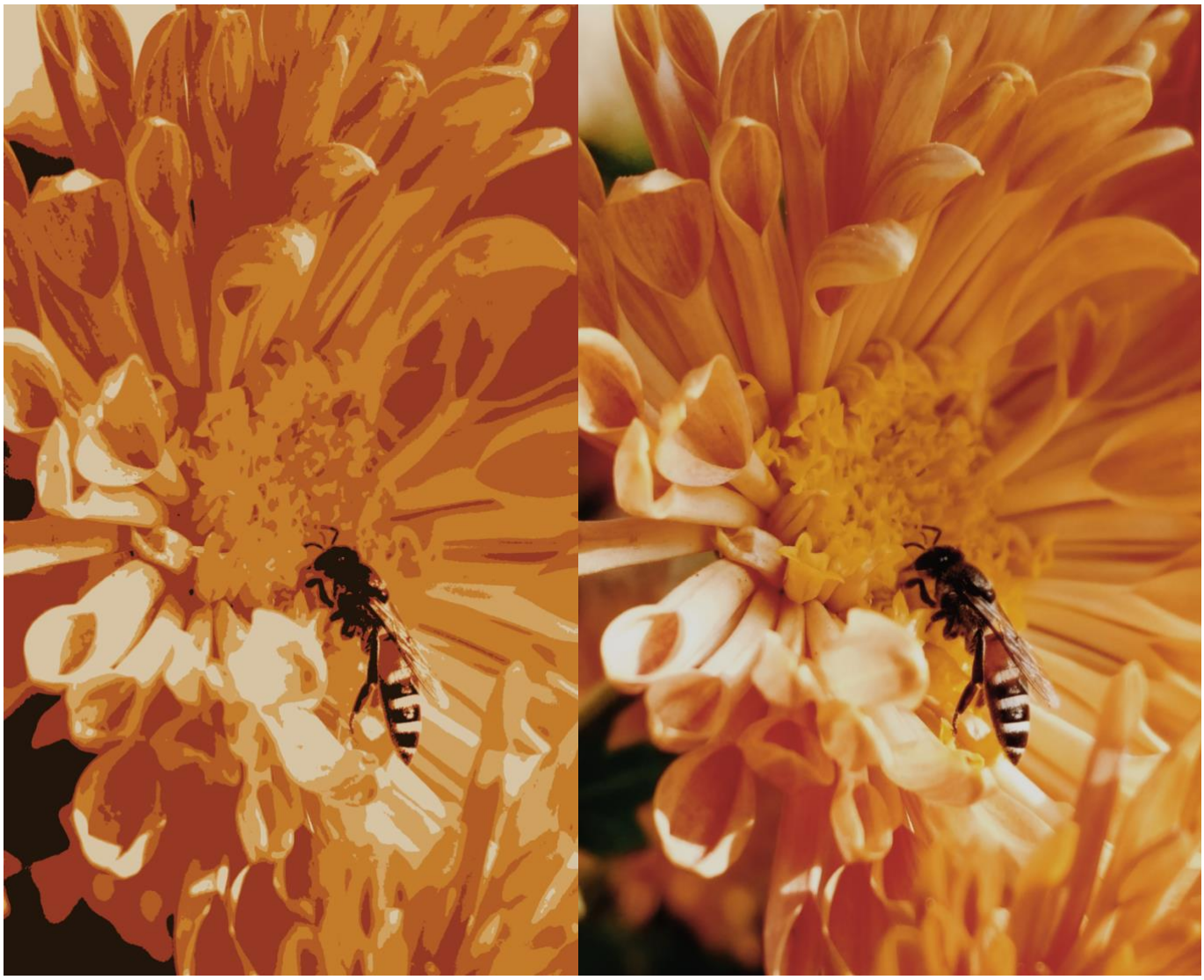

Figure 3: Compressed Image (left) vs. Original Image (right)

$k = 8$

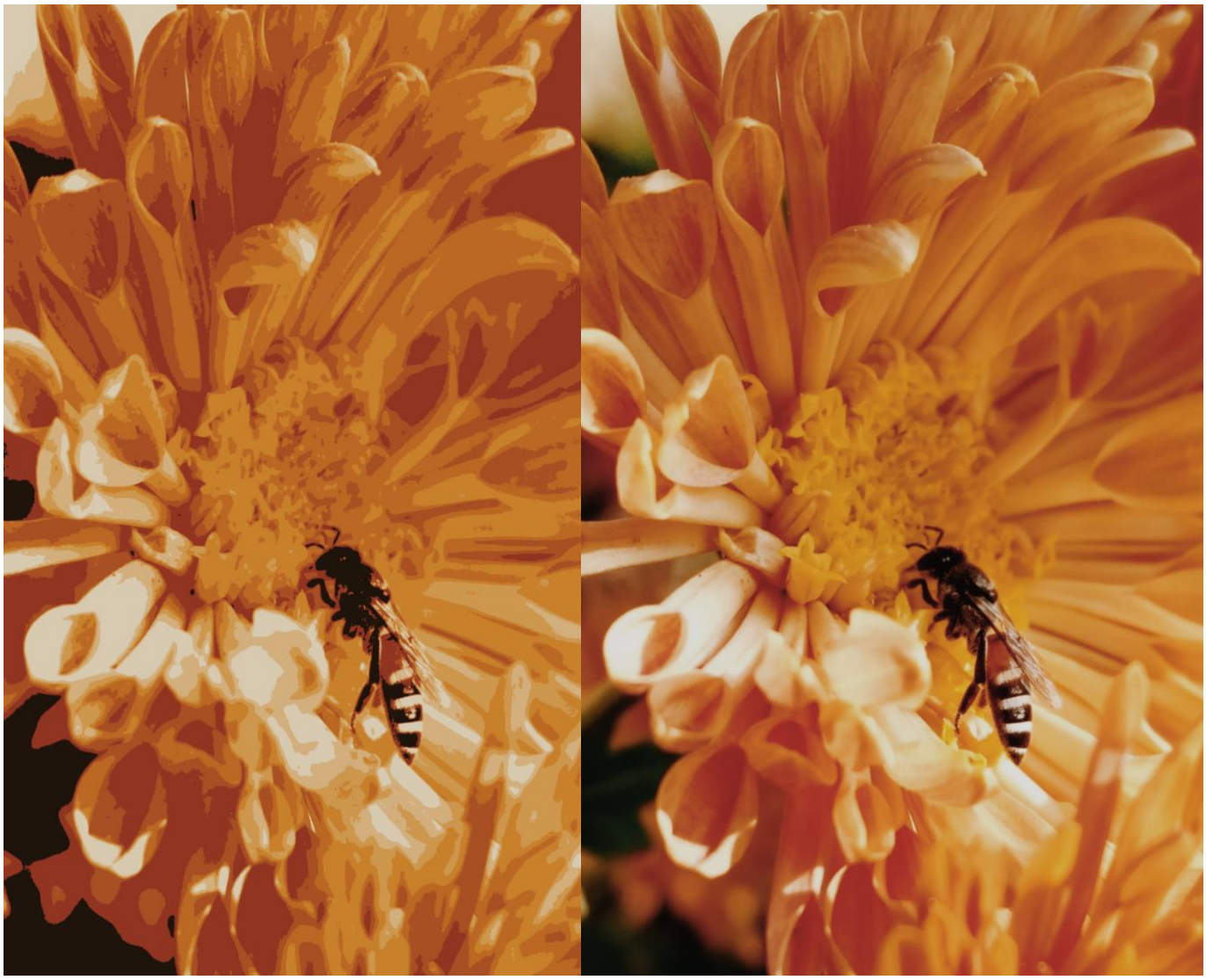

Figure 4: Compressed Image (left) vs. Original Image (right)

k = 10

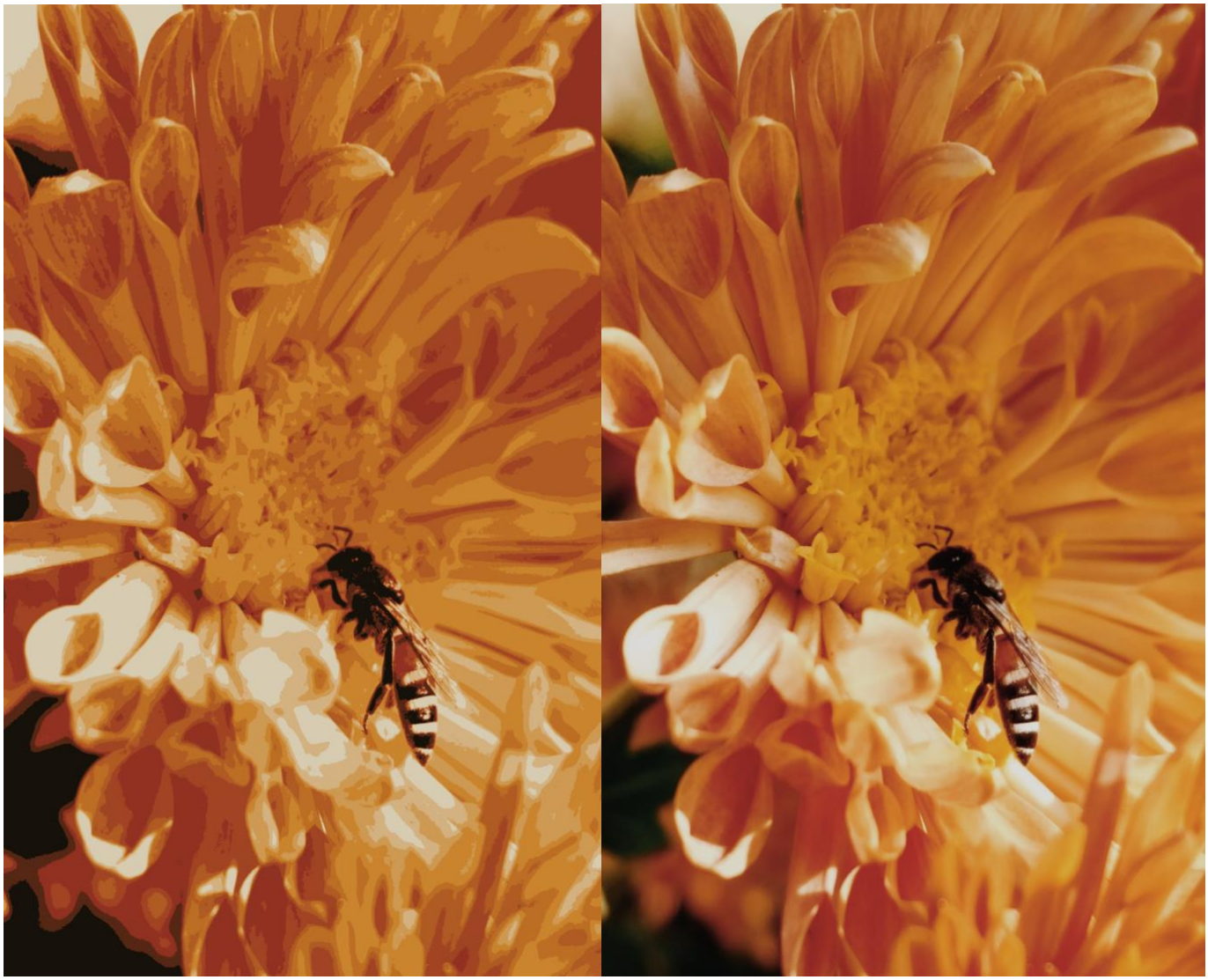

Figure 5: Compressed Image (left) vs. Original Image (right)

PCA:

Number of components = 10

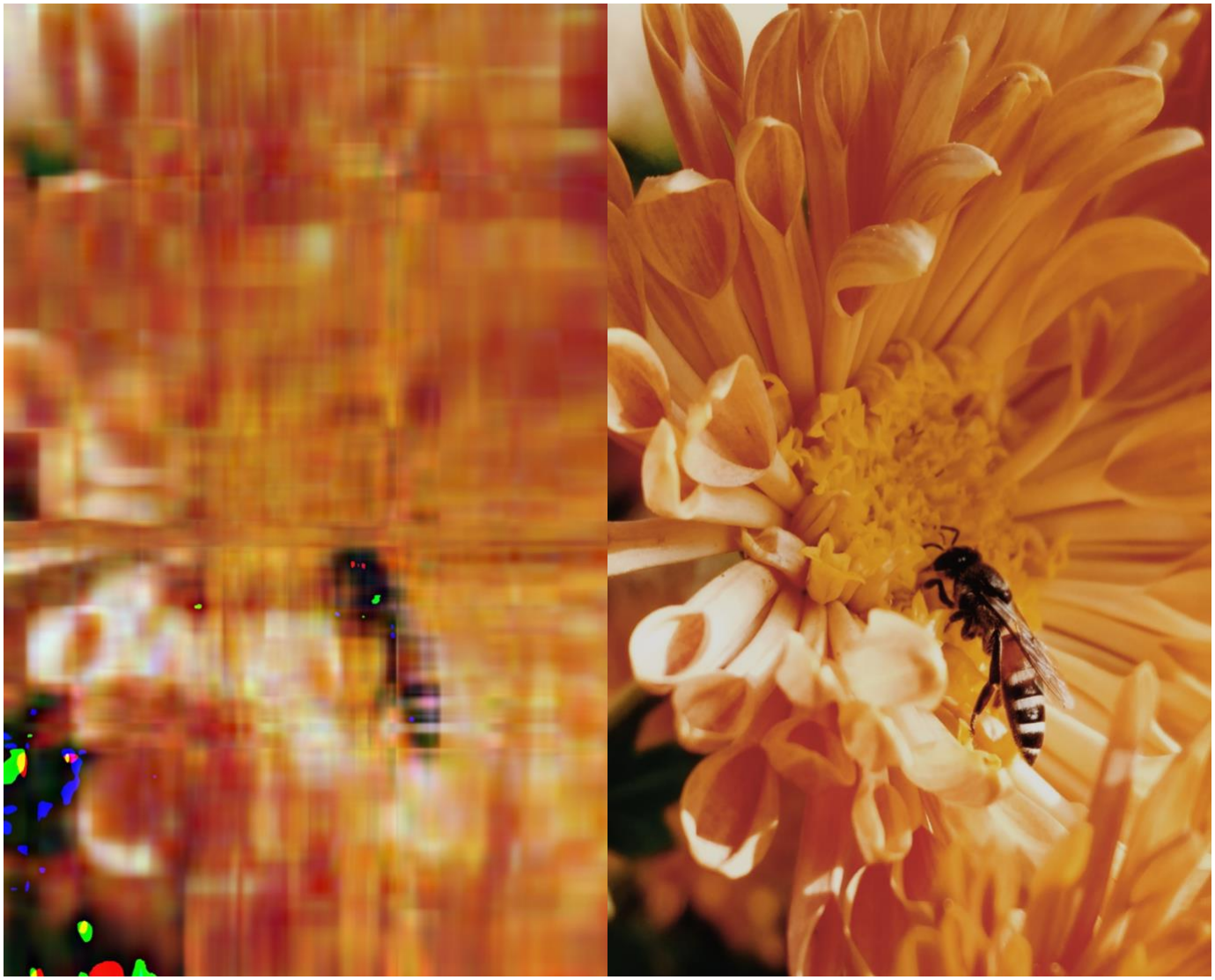

Figure 6: Compressed Image (left) vs. Original Image (right)

Number of components = 20

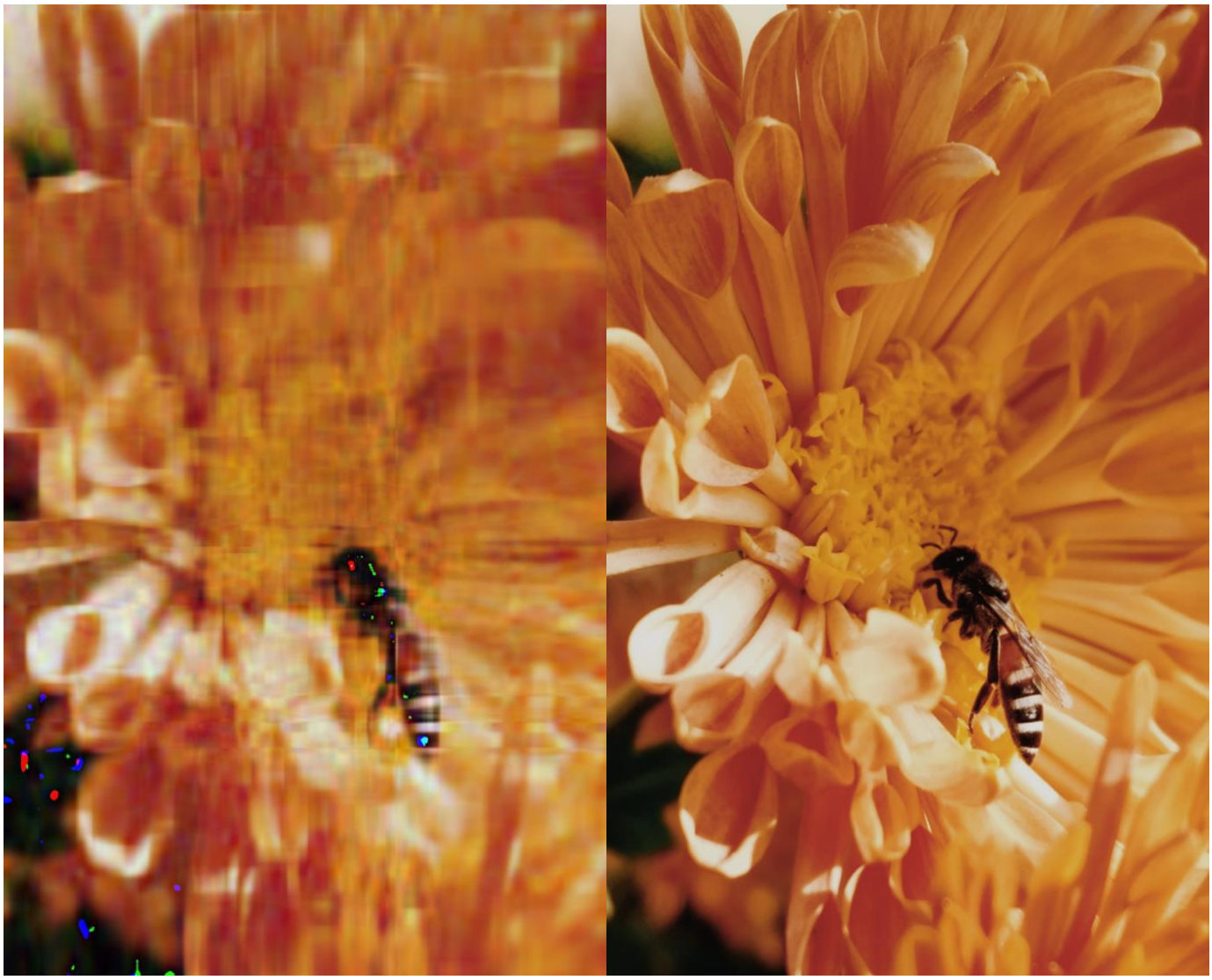

Figure 7: Compressed Image (left) vs. Original Image (right)

Number of components = 50

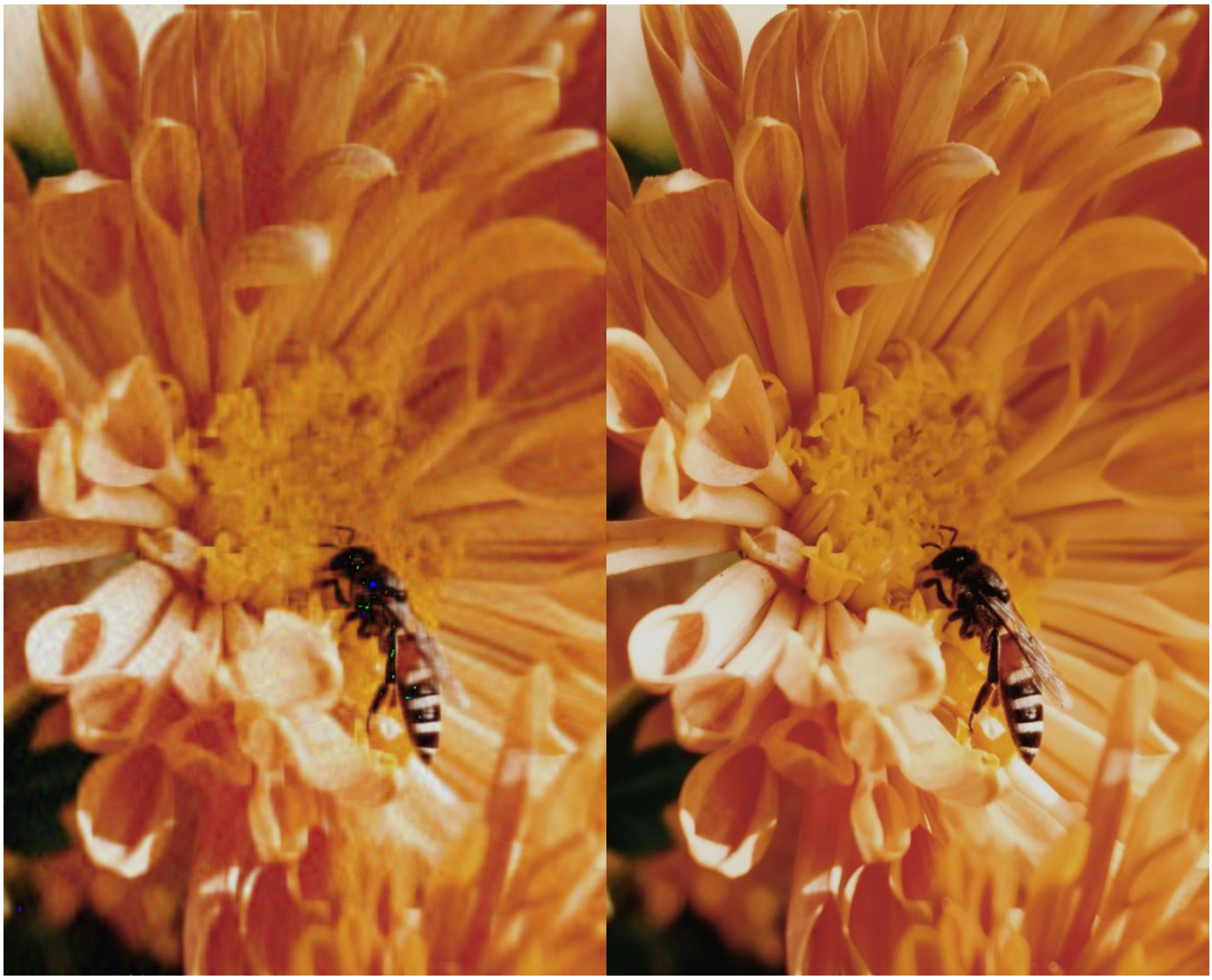

Figure 8: Compressed Image (left) vs. Original Image (right)

Number of components = 75

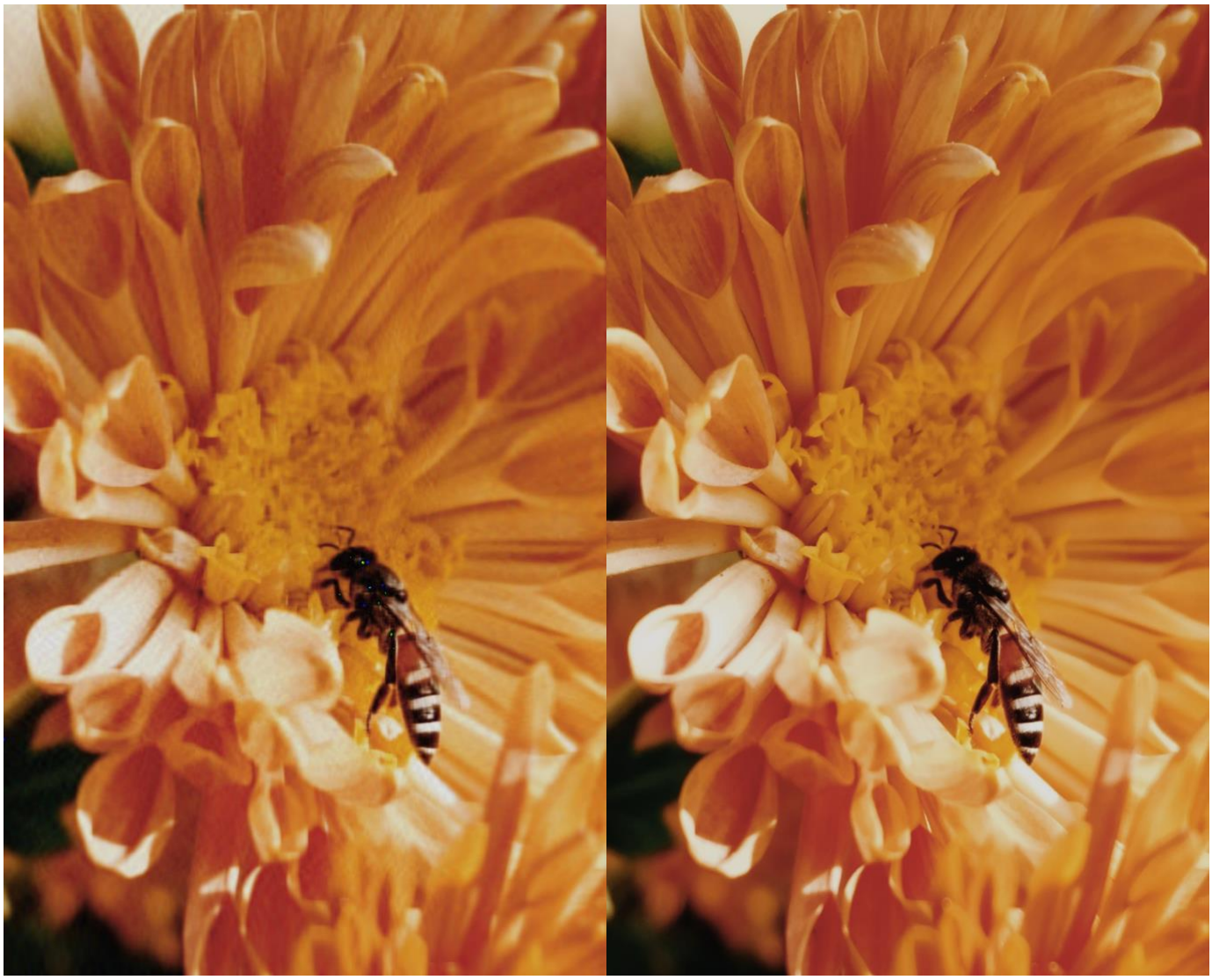

Figure 9: Compressed Image (left) vs. Original Image (right)

Number of components = 100

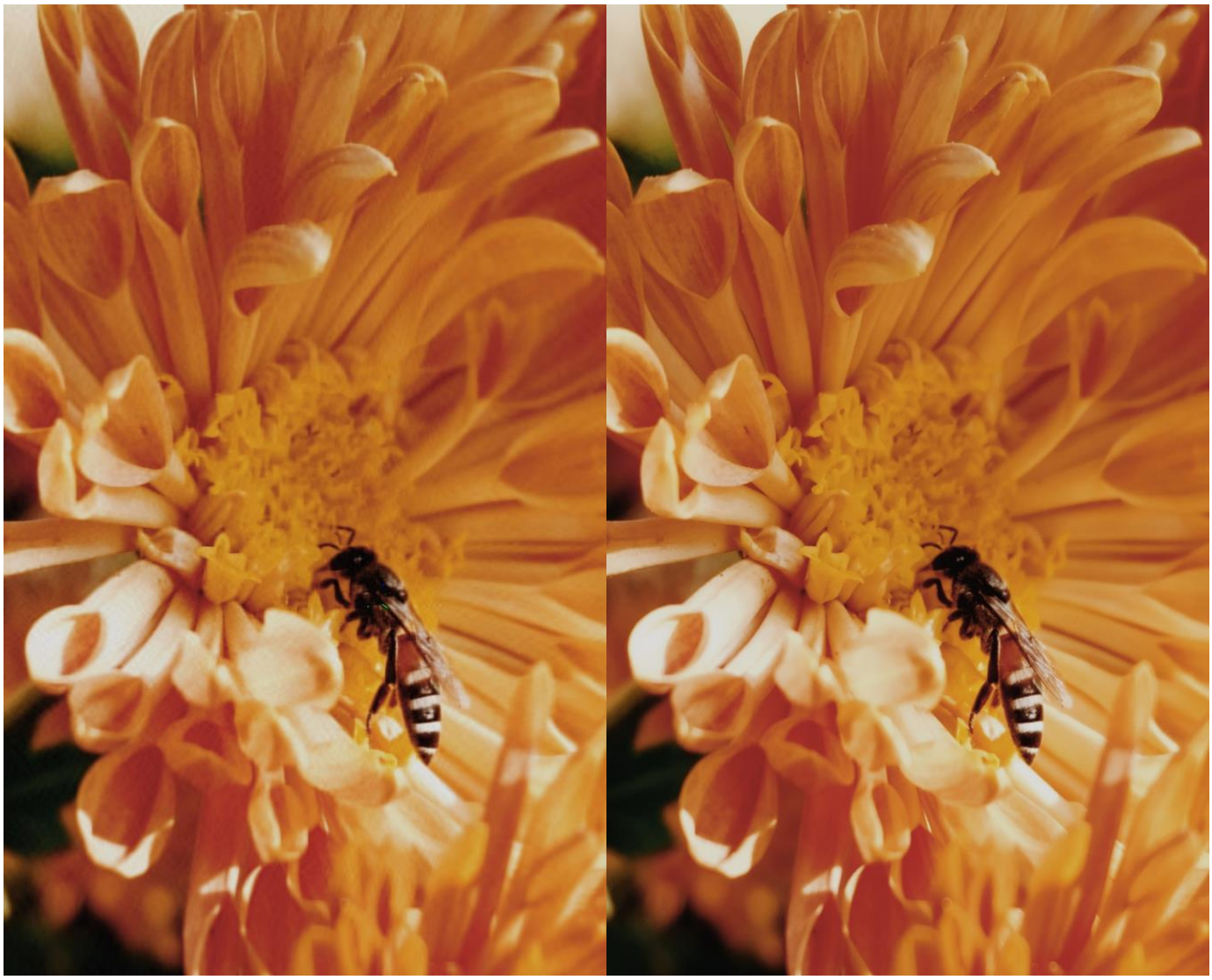

Figure 10: Compressed Image (left) vs. Original Image (right)

Number of components = 150

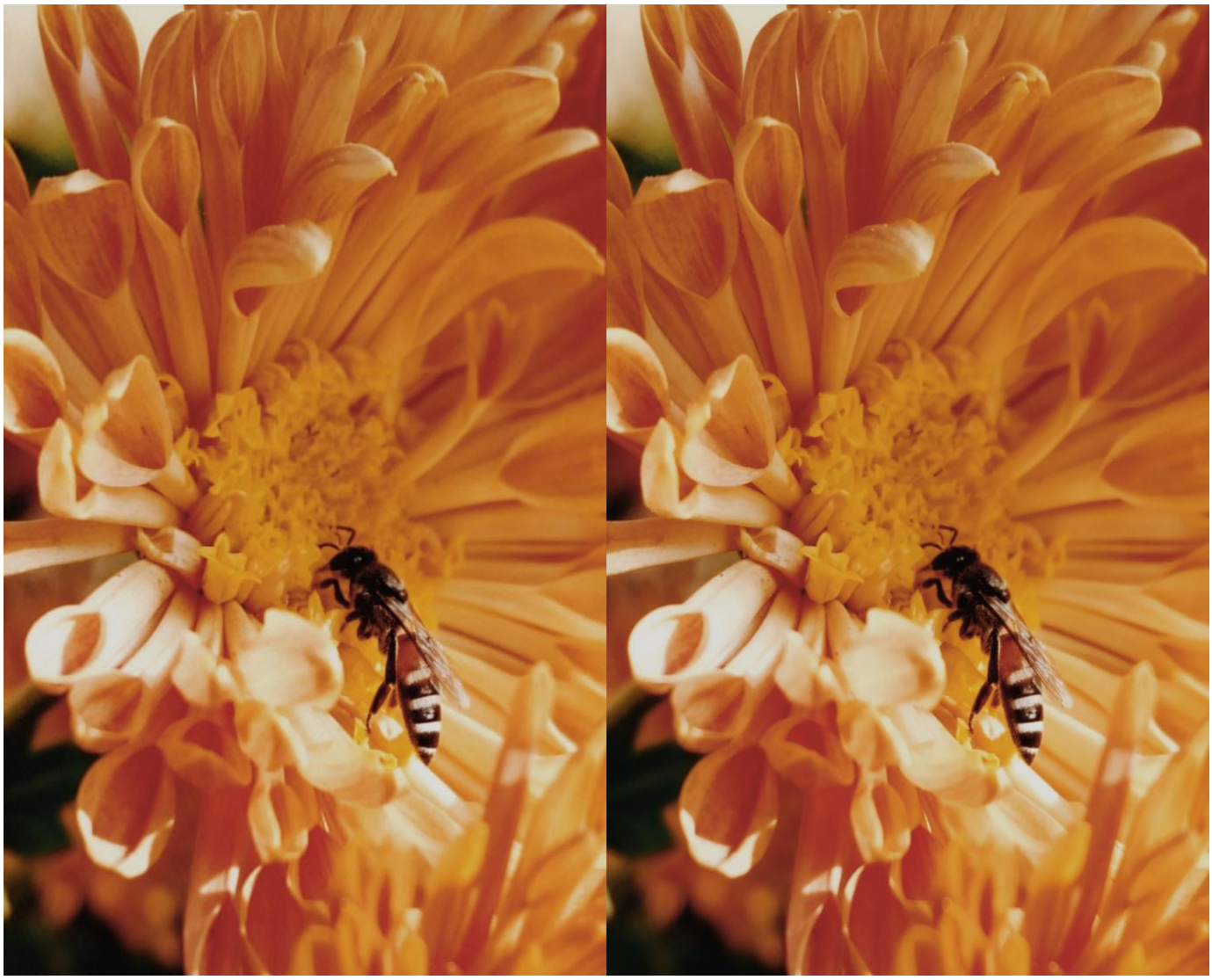

Figure 11: Compressed Image (left) vs. Original Image (right)

4. TEST RESULTS

k-Means Clustering:

K	Image Size	Visual Quality
2	186 KB	Most details of the image have been lost, it is not possible to determine the objects in the image
4	505 KB	The large objects in the image are visible but the fine details as well as most of the colours have been lost
6	868 KB	The large objects in the image as well as the main colours are visible. The clarity is low and the edges of the objects are fuzzy
8	1.2 MB	While the main objects in the image are discernible, details such as the shadows, lighting, and boundaries of the objects are not clear
10	1.4 MB	The principal objects in the image have been retained, along with some of the fine-grained details. However, the precise details of the image are hazy

PCA:

N	Image Size	Visual Quality
10	6.1 MB	The image is highly pixelated and no objects can be perceived
20	6.8 MB	While the large objects in the image are discernible, the quality is poor. The image is very blurred
50	7.5 MB	Although a majority of the details have been retained, the image is grainy
75	7.8 MB	The image quality is adequate. All details of the image are preserved, but the image is not flawless
100	8.0 MB	The visual quality is satisfactory, but the image is slightly grainy
150	8.2 MB	The image is high quality, no details have been lost in compression. Extremely close observation reveals slight blurring

5. INTERPRETATION OF RESULTS

Image Size:

Using k-means clustering, we can achieve excellent reduction in image size. With values of k varying from 2 to 10, the image can be compressed to less than $1/8^{th}$ of its original size while managing to retain most of the relevant details of the original image.
On the other hand, when we use PCA, even with the number of components set to a value as low as 10, which results in a highly noisy image, the compressed image size does not go below 6 MB. That is, the lowest quality compressed image is still nearly $3/4^{th}$ of its original size.

Visual Quality:

With k-means clustering, the visual quality is not satisfactory. The lower values of k produce blurry images in which most details have been lost. The highest value of k used was 10, and this results in a compressed image that, while retaining an adequate amount of information from the original image, resembles a painted version of the original.
PCA compression produces images of a very high quality in comparison. If we set the number of components to 50 or less, the resulting image is highly pixelated. However, on increasing the number of components to 75, 100, and 150, we obtain an image that is increasingly close to the original in terms of visual quality. All details, including fine-grained ones, are retained.

6. CONCLUSION AND USE OF EACH METHOD

On comparing the compressed images obtained using k-means and the images obtained using PCA, we can conclude that while k-means produces a better reduction in size, PCA results in a compressed image of higher visual quality.

K-means can be used for the purpose of image segmentation. As we have observed, the images produced using the k-means clustering algorithm preserve the larger – or more relevant – objects of the original image, while the quality of the objects in the background is reduced, for the most part. Therefore we can see that k-means can be used to segment the areas of interest from the background. In addition, k-means can be used when the image needs to be significantly compressed but retaining the visual quality is not a key requirement. On the other hand, PCA can be used when the visual quality of the compressed image is the foremost requirement. The images produced using PCA have a very high visual quality – comparable with the original image. PCA compresses the image, while retaining almost all the original data. However, it is not a suitable technique in cases where the size of the compressed image is pertinent.

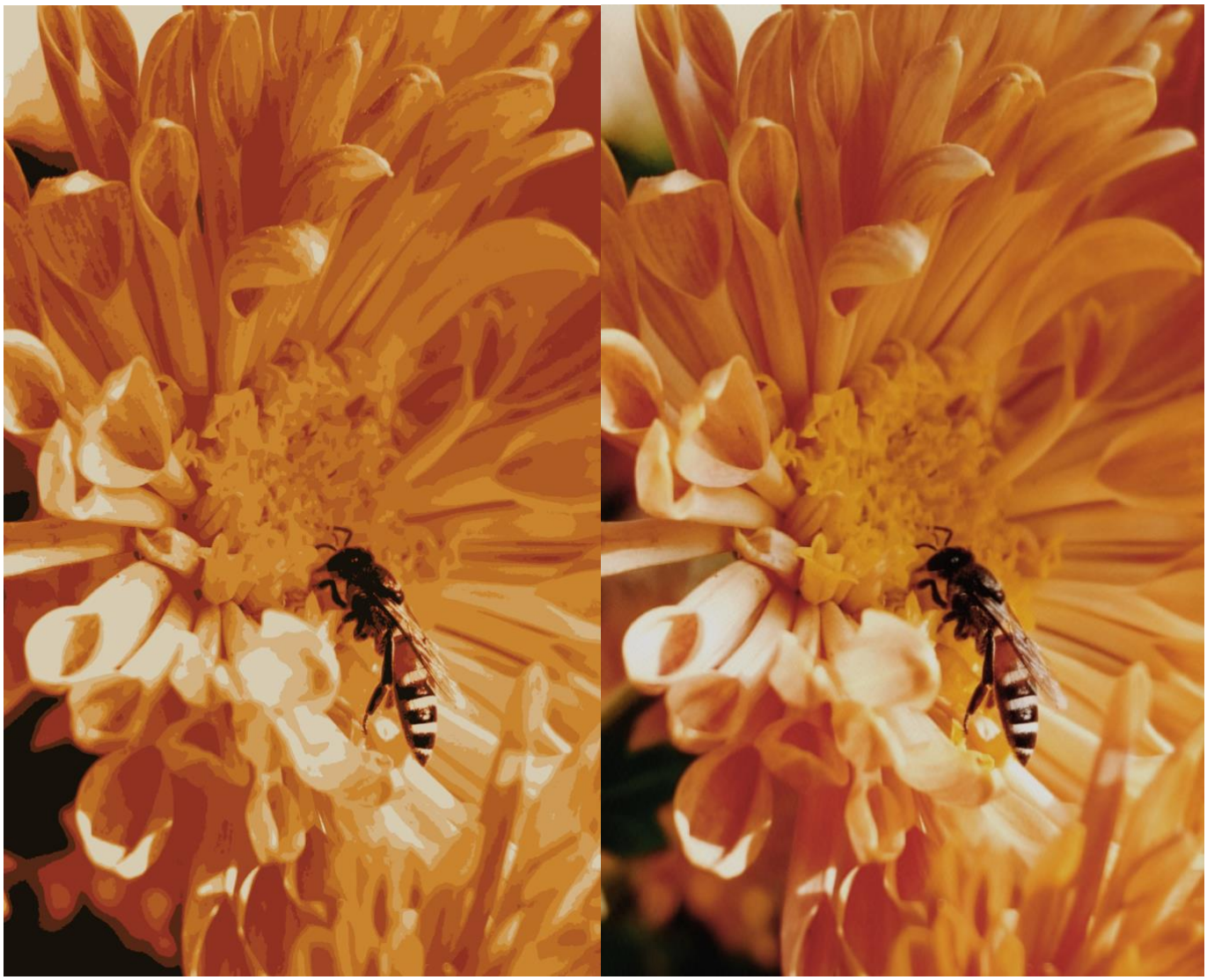

Figure 12: k-means Compressed Image (left) vs. PCA Compressed Image (right)