In [1]:
```
from tensorflow import keras
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.preprocessing import image
#from tensorflow.keras.applications.inception_v3 import InceptionV3, preprocess_i
from tensorflow.keras.applications.inception_resnet_v2 import InceptionResNetV2,
from tensorflow.keras.layers import Dense, Flatten
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adam
import numpy as np
import random
import matplotlib.pyplot as plt
%matplotlib inline
```

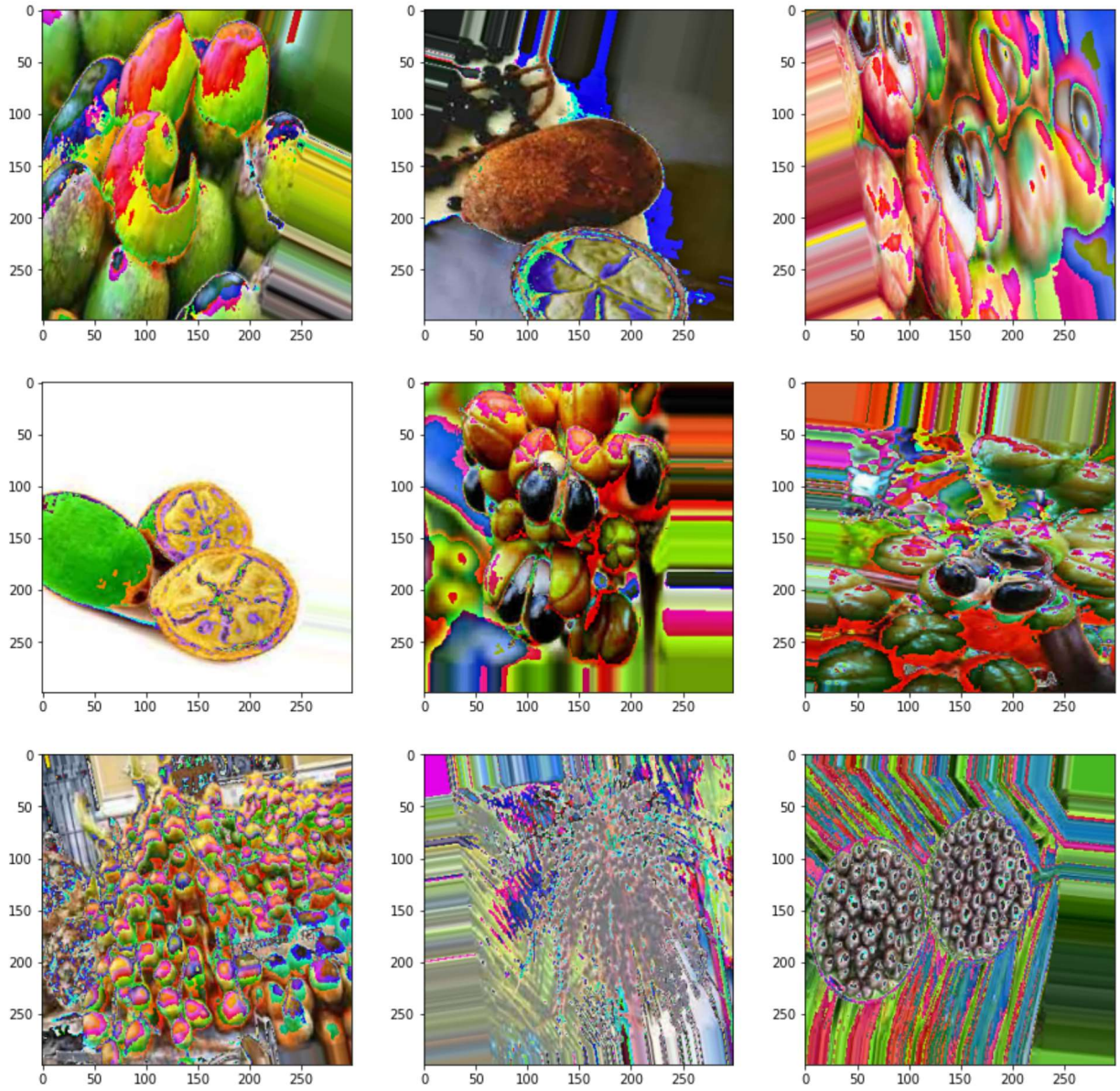
In [2]:
```
im_shape = (299,299)

TRAINING_DIR = 'input/ds_frutas_am/train'
TEST_DIR = 'input/ds_frutas_am/test'

seed = 10

BATCH_SIZE = 16
```

In [3]:
```
data_generator = ImageDataGenerator(
        validation_split=0.2,
        rotation_range=20,
        width_shift_range=0.2,
        height_shift_range=0.2,
        preprocessing_function=preprocess_input,
        shear_range=0.2,
        zoom_range=0.2,
        horizontal_flip=True,
        fill_mode='nearest')
val_data_generator = ImageDataGenerator(preprocessing_function=preprocess_input,v
```

In [4]:
```
train_generator = data_generator.flow_from_directory(TRAINING_DIR, target_size=in
                                                     class_mode='categorical', ba
# Generator para parte validação
validation_generator = val_data_generator.flow_from_directory(TRAINING_DIR, targe
                                                     class_mode='categorical', ba

# Generator para dataset de teste
test_generator = ImageDataGenerator(preprocessing_function=preprocess_input)
test_generator = test_generator.flow_from_directory(TEST_DIR, target_size=im_shap
                                                     class_mode='categorical', ba

nb_train_samples = train_generator.samples
nb_validation_samples = validation_generator.samples
nb_test_samples = test_generator.samples
classes = list(train_generator.class_indices.keys())
print('Classes: '+str(classes))
num_classes  = len(classes)
```

```
Found 72 images belonging to 6 classes.
Found 18 images belonging to 6 classes.
Found 30 images belonging to 6 classes.
Classes: ['acai', 'cupuacu', 'graviola', 'guarana', 'pupunha', 'tucuma']
```

In [5]:
```
plt.figure(figsize=(15,15))
for i in range(9):
    #gera subfigures
    plt.subplot(330 + 1 + i)
    batch = train_generator.next()[0]*255
    image = batch[0].astype('uint8')
    plt.imshow(image)
plt.show()
```



In [6]:
```
base_model = InceptionResNetV2(weights='imagenet', include_top=False, input_shape

x = base_model.output
x = Flatten()(x)
x = Dense(100, activation='relu')(x)
predictions = Dense(num_classes, activation='softmax', kernel_initializer='randon

model = Model(inputs=base_model.input, outputs=predictions)

# Freezing pretrained layers
for layer in base_model.layers:
    layer.trainable=False

optimizer = Adam()
model.compile(optimizer=optimizer,loss='categorical_crossentropy',metrics=['accur
```

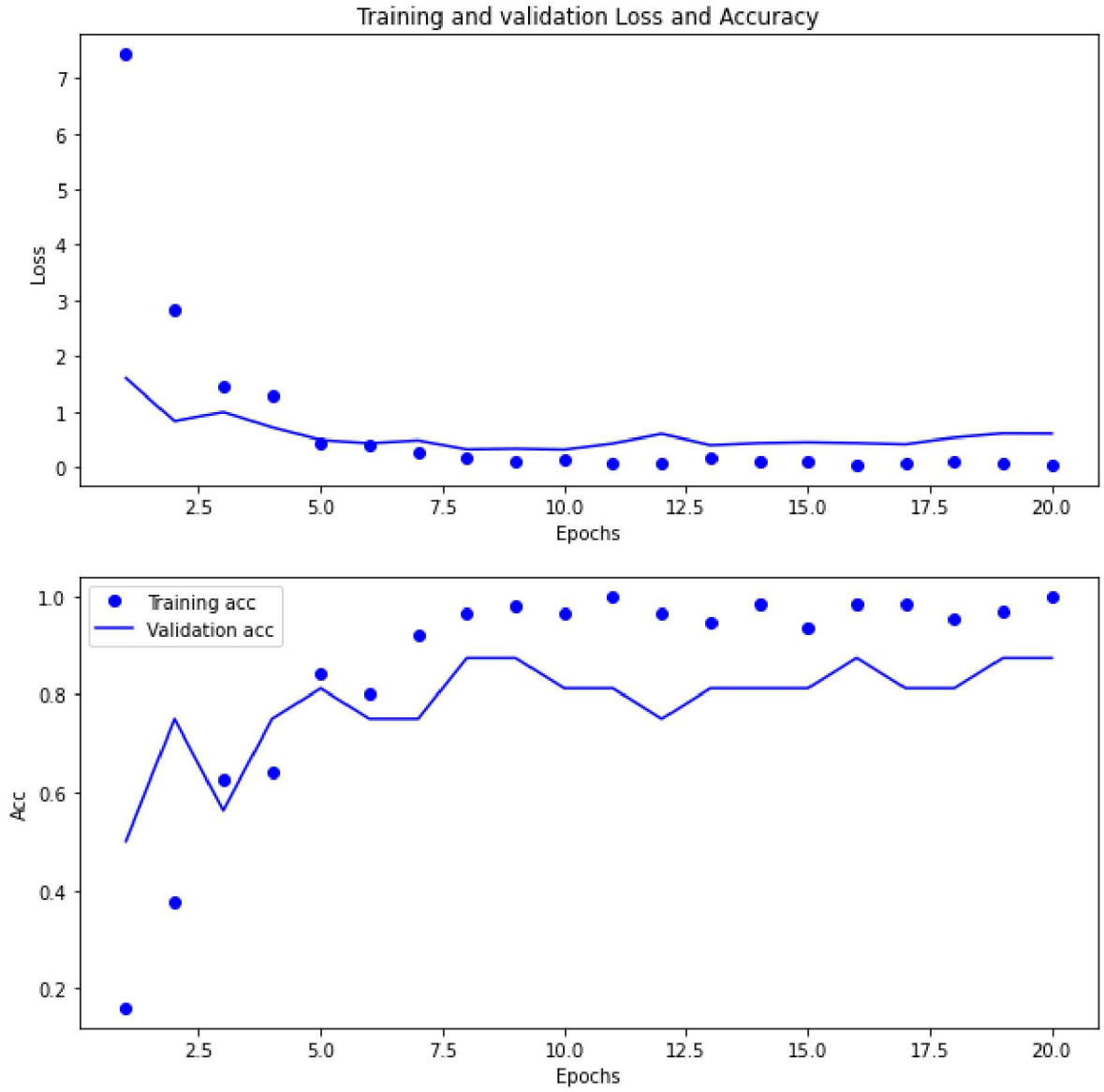
In [7]:
```
epochs = 80

# Saving the best model
callbacks_list = [
    keras.callbacks.ModelCheckpoint(
        filepath='model.h5',
        monitor='val_loss', save_best_only=True, verbose=1),
    keras.callbacks.EarlyStopping(monitor='val_loss', patience=10,verbose=1)
]

history = model.fit(
        train_generator,
        steps_per_epoch=nb_train_samples // BATCH_SIZE,
        epochs=epochs,
        callbacks = callbacks_list,
        validation_data=validation_generator,
        verbose = 1,
        validation_steps=nb_validation_samples // BATCH_SIZE)
```

```
Epoch 1/80
4/4 [==============================] - 23s 5s/step - loss: 7.4154 - accuracy:
0.1607 - val_loss: 1.6049 - val_accuracy: 0.5000

Epoch 00001: val_loss improved from inf to 1.60493, saving model to model.h5
Epoch 2/80
4/4 [==============================] - 15s 4s/step - loss: 2.8204 - accuracy:
0.3750 - val_loss: 0.8299 - val_accuracy: 0.7500

Epoch 00002: val_loss improved from 1.60493 to 0.82993, saving model to mode
l.h5
Epoch 3/80
4/4 [==============================] - 16s 4s/step - loss: 1.4580 - accuracy:
0.6250 - val_loss: 0.9950 - val_accuracy: 0.5625

Epoch 00003: val_loss did not improve from 0.82993
Epoch 4/80
4/4 [==============================] - 15s 4s/step - loss: 1.2795 - accuracy:
0.6429 - val_loss: 0.7187 - val_accuracy: 0.7500

Epoch 00004: val_loss improved from 0.82993 to 0.71871, saving model to mode
l.h5
Epoch 5/80
4/4 [==============================] - 16s 4s/step - loss: 0.4444 - accuracy:
0.8438 - val_loss: 0.4923 - val_accuracy: 0.8125

Epoch 00005: val_loss improved from 0.71871 to 0.49233, saving model to mode
l.h5
Epoch 6/80
4/4 [==============================] - 14s 4s/step - loss: 0.4118 - accuracy:
0.8036 - val_loss: 0.4362 - val_accuracy: 0.7500

Epoch 00006: val_loss improved from 0.49233 to 0.43619, saving model to mode
l.h5
Epoch 7/80
4/4 [==============================] - 16s 4s/step - loss: 0.2808 - accuracy:
0.9219 - val_loss: 0.4858 - val_accuracy: 0.7500
```

```
Epoch 00007: val_loss did not improve from 0.43619
Epoch 8/80
4/4 [==============================] - 14s 4s/step - loss: 0.1838 - accuracy:
0.9643 - val_loss: 0.3260 - val_accuracy: 0.8750

Epoch 00008: val_loss improved from 0.43619 to 0.32599, saving model to mode
l.h5
Epoch 9/80
4/4 [==============================] - 15s 4s/step - loss: 0.0968 - accuracy:
0.9821 - val_loss: 0.3381 - val_accuracy: 0.8750

Epoch 00009: val_loss did not improve from 0.32599
Epoch 10/80
4/4 [==============================] - 14s 4s/step - loss: 0.1527 - accuracy:
0.9643 - val_loss: 0.3221 - val_accuracy: 0.8125

Epoch 00010: val_loss improved from 0.32599 to 0.32210, saving model to mode
l.h5
Epoch 11/80
4/4 [==============================] - 14s 4s/step - loss: 0.0797 - accuracy:
1.0000 - val_loss: 0.4329 - val_accuracy: 0.8125

Epoch 00011: val_loss did not improve from 0.32210
Epoch 12/80
4/4 [==============================] - 14s 4s/step - loss: 0.0874 - accuracy:
0.9643 - val_loss: 0.6007 - val_accuracy: 0.7500

Epoch 00012: val_loss did not improve from 0.32210
Epoch 13/80
4/4 [==============================] - 15s 4s/step - loss: 0.1650 - accuracy:
0.9464 - val_loss: 0.4024 - val_accuracy: 0.8125

Epoch 00013: val_loss did not improve from 0.32210
Epoch 14/80
4/4 [==============================] - 16s 4s/step - loss: 0.1140 - accuracy:
0.9844 - val_loss: 0.4402 - val_accuracy: 0.8125

Epoch 00014: val_loss did not improve from 0.32210
Epoch 15/80
4/4 [==============================] - 16s 4s/step - loss: 0.1175 - accuracy:
0.9375 - val_loss: 0.4537 - val_accuracy: 0.8125

Epoch 00015: val_loss did not improve from 0.32210
Epoch 16/80
4/4 [==============================] - 16s 4s/step - loss: 0.0485 - accuracy:
0.9844 - val_loss: 0.4402 - val_accuracy: 0.8750

Epoch 00016: val_loss did not improve from 0.32210
Epoch 17/80
4/4 [==============================] - 16s 4s/step - loss: 0.0728 - accuracy:
0.9844 - val_loss: 0.4187 - val_accuracy: 0.8125

Epoch 00017: val_loss did not improve from 0.32210
Epoch 18/80
4/4 [==============================] - 16s 4s/step - loss: 0.1026 - accuracy:
0.9531 - val_loss: 0.5357 - val_accuracy: 0.8125
```

```
Epoch 00018: val_loss did not improve from 0.32210
Epoch 19/80
4/4 [==============================] - 16s 4s/step - loss: 0.0752 - accuracy:
0.9688 - val_loss: 0.6095 - val_accuracy: 0.8750

Epoch 00019: val_loss did not improve from 0.32210
Epoch 20/80
4/4 [==============================] - 15s 4s/step - loss: 0.0392 - accuracy:
1.0000 - val_loss: 0.6059 - val_accuracy: 0.8750

Epoch 00020: val_loss did not improve from 0.32210
Epoch 00020: early stopping
```

In [8]:
```
import matplotlib.pyplot as plt

history_dict = history.history
loss_values = history_dict['loss']
val_loss_values = history_dict['val_loss']

epochs_x = range(1, len(loss_values) + 1)
plt.figure(figsize=(10,10))
plt.subplot(2,1,1)
plt.plot(epochs_x, loss_values, 'bo', label='Training loss')
plt.plot(epochs_x, val_loss_values, 'b', label='Validation loss')
plt.title('Training and validation Loss and Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Loss')
#plt.legend()
plt.subplot(2,1,2)
acc_values = history_dict['accuracy']
val_acc_values = history_dict['val_accuracy']
plt.plot(epochs_x, acc_values, 'bo', label='Training acc')
plt.plot(epochs_x, val_acc_values, 'b', label='Validation acc')
#plt.title('Training and validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Acc')
plt.legend()
plt.show()
```



In [9]:
```
from tensorflow.keras.models import load_model
# Load the best saved model
model = load_model('model.h5')
```

In [10]:
```
score = model.evaluate_generator(validation_generator)
print('Val loss:', score[0])
print('Val accuracy:', score[1])
```

```
c:\users\hp\appdata\local\programs\python\python39\lib\site-packages\keras\engi
ne\training.py:2006: UserWarning: `Model.evaluate_generator` is deprecated and
will be removed in a future version. Please use `Model.evaluate`, which support
s generators.
  warnings.warn('`Model.evaluate_generator` is deprecated and '

Val loss: 0.323172926902771
Val accuracy: 0.8333333134651184
```

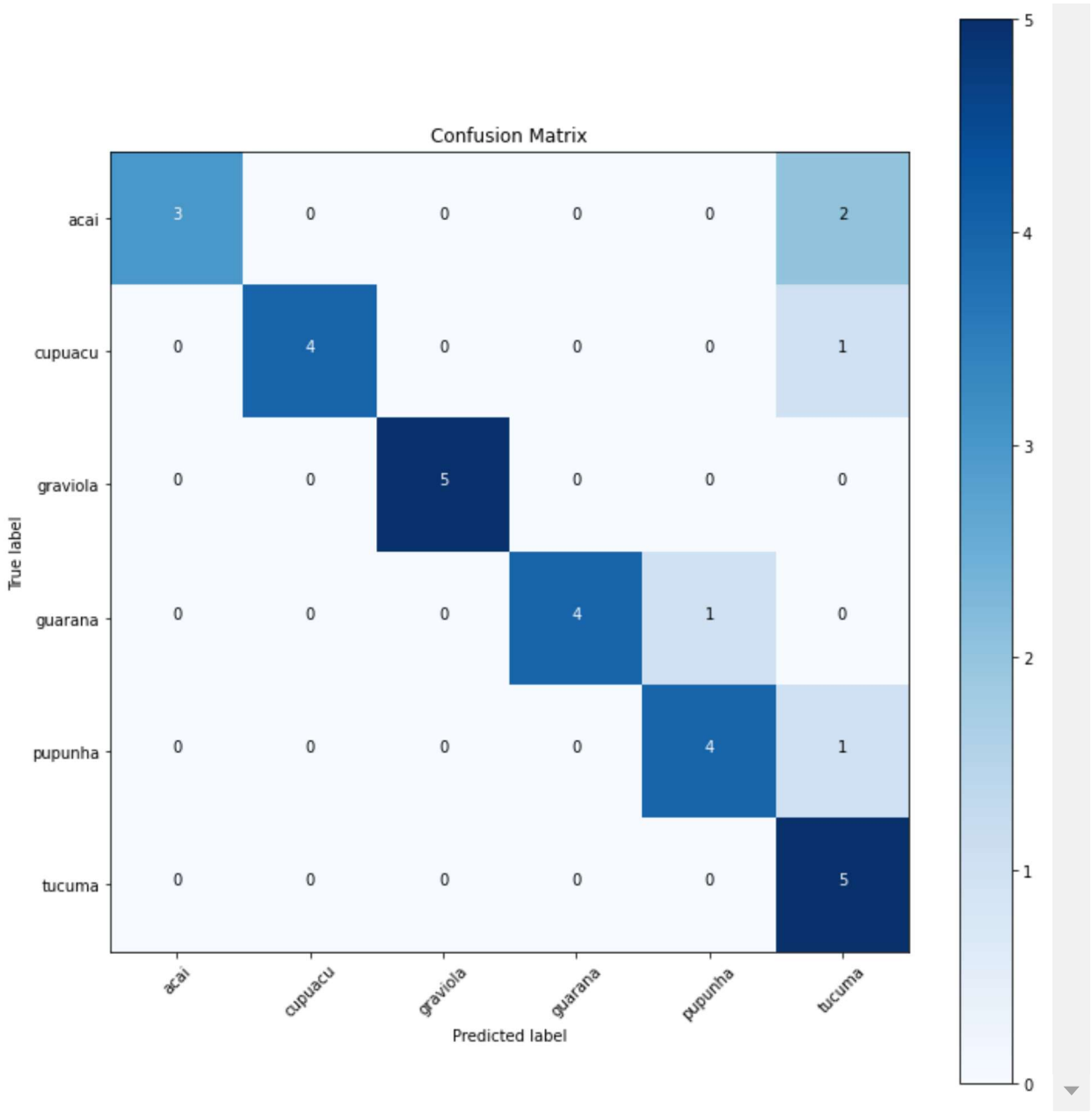
In [11]:
```
score = model.evaluate_generator(test_generator)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
Test loss: 0.37131157517433167
Test accuracy: 0.8333333134651184
```

In [12]:
```
import itertools

#Plot the confusion matrix. Set Normalize = True/False
def plot_confusion_matrix(cm, classes, normalize=True, title='Confusion matrix',
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    plt.figure(figsize=(10,10))
    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=45)
    plt.yticks(tick_marks, classes)
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        cm = np.around(cm, decimals=2)
        cm[np.isnan(cm)] = 0.0
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, cm[i, j],
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")
    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
```

In [13]:
```
from sklearn.metrics import classification_report, confusion_matrix
import numpy as np

#Confution Matrix and Classification Report
Y_pred = model.predict_generator(test_generator)#, nb_test_samples // BATCH_SIZE,
y_pred = np.argmax(Y_pred, axis=1)
target_names = classes

#Confution Matrix
cm = confusion_matrix(test_generator.classes, y_pred)
plot_confusion_matrix(cm, target_names, normalize=False, title='Confusion Matrix'
print('Classification Report')
print(classification_report(test_generator.classes, y_pred, target_names=target_r
```

```
c:\users\hp\appdata\local\programs\python\python39\lib\site-packages\keras\engi
ne\training.py:2035: UserWarning: `Model.predict_generator` is deprecated and w
ill be removed in a future version. Please use `Model.predict`, which supports
generators.
  warnings.warn('`Model.predict_generator` is deprecated and '

Classification Report
              precision    recall  f1-score   support

        acai       1.00      0.60      0.75         5
     cupuacu       1.00      0.80      0.89         5
    graviola       1.00      1.00      1.00         5
     guarana       1.00      0.80      0.89         5
     pupunha       0.80      0.80      0.80         5
      tucuma       0.56      1.00      0.71         5

    accuracy                           0.83        30
   macro avg       0.89      0.83      0.84        30
weighted avg       0.89      0.83      0.84        30
```


Confusion Matrix
acai
cupuacu
graviola
guarana
pupunha
tucuma
True label
Predicted label
3 0 0 0 0 2
0 4 0 0 0 1
0 0 5 0 0 0
0 0 0 4 1 0
0 0 0 0 4 1
0 0 0 0 0 5
5
4
3
2
1
0

In [ ]: