

Callus, Calluses or Calli: Multiple Plurals?

Jaime A. Teixeira da Silva

Faculty of Agriculture and Graduate School of Agriculture, Kagawa University, Miki-Cho, Ikenobe, 2393, Kagawa-Ken, 761-0795, Japan

Corresponding author: * jaimetex@yahoo.com

ABSTRACT

In plant tissue culture, the disorganized (or undifferentiated) tissue that forms in response to stress or a whole array of *in vitro* treatments results in the formation of a disorganized mass of tissues, or callus, in both solid and liquid media. In animal and human bodies, it could also be referred to as cancer (in terms of disorganized growth) or callus (in terms of hardened growth). However, the plural form of the word callus, if we were to follow strict Latin rules, would be calli, or the Anglicized form (US or UK) would be calluses. Despite this, the term callus and calli are used very loosely in the literature when referring to the plural (> 1). I propose that the term callus be used in singular and plural form to describe the process and the object, and even in the plural form to describe unquantifiable masses of callus. In other words, I do not advocate the use of the term calli. For example, callus formed on leaf explants; callus tissue was removed from leaf explants; a large amount of callus formed on leaf explants. Should the singular and plural form be treated as one term in English, as for sheep, fish or pollen, in which the singular and plural forms are treated equally? In which cases could calluses be used? I examine this discrepancy in more detail in this short paper.

Keywords: undifferentiated cell growth

INTRODUCTION

In plant tissue culture, an explant is often plated on medium under *in vitro* conditions and can form, often in response to one or multiple plant growth regulators, or other stimuli, callus, or disorganized cell growth. Since growth is disorganized, i.e., in a state of de-differentiation, it would not be correct to refer to it as a tissue, only as a mass of disorganized cells. Histologically, a somatic cell, in response to a stress, nutrition or plant growth regulator within an artificial medium can change to become a meristematic cell via the process of dedifferentiation. The origin is from one meristematic cell that divides actively and, in some cases, produces disorganized and unquantifiable masses, termed callus. Even though, visually, the size of the callus can vary, the callus itself originates from several meristematic cells, suggesting that the term callus can be used both in singular and plural forms. Since callus is made up of a mass of unquantifiable number of cells, and since a mass of callus can be divided into multiple masses of cells that can themselves re-divide to form new callus, it is practically difficult to suggest if callus is quantifiable/countable, or unquantifiable/uncountable. One cell within a callus mass would not constitute callus, but would 3 or 4 cells constitute callus? The lower limit of the number of cells that constitutes callus has never been defined in the literature, and most likely never will. Another issue relates to a cell suspension. Soft, friable callus, which has some structure on a solid medium, one placed in liquid medium (such as a bioreactor or shake culture), dissolves into individual cells or much smaller cell clusters, which would be termed a cell suspension culture. Should this still be termed callus? In this case, I believe not, even though the origin was from callus; it should be termed a cell suspension culture. Within a callus, even though collectively, the callus mass might not display “organized” growth, or a specific structure (tissue or organ), individual cells are in active division and are organized. In essence, each cell would be in a state of “preparedness”, and would respond to a stimulus (light, plant growth regulator, etc.),

biotic or abiotic, which would then activate the process of organized differentiation to form a shoot, root, leaf, protocorm-like body, etc. *in vitro*. The term callus may have other connotations in human or animals systems, which will not form part of this discussion. I explore these discrepancies in a little more detail in this short paper.

Webster’s dictionary states clearly that the word “calluses” is the plural form of “callus”. Other Internet sources indicate either calluses or calli, but not the use of the term callus as both the plural and singular forms. In limited contexts, to represent a “collective term”, the single form could be used to represent the plural (e.g. callus formed on leaf explants; callus developed on 10 root explants). Would “callus tissue” or “callus” be correct to use when stating “callus was removed” vs “callus tissue was removed”? In this case, the former would be correct since callus is a disorganized mass of cells or tissue that is in a state of de-differentiation, thus the term “tissue” would be somewhat redundant. This fortifies the use of the term “callus” to describe both singular and plural forms of the concept and the object. Certainly, one would not describe several cultures that are established from callus as “calluses cultures”. In all these cases, we are dealing with unquantifiable values, or “uncountable” nouns. Therefore, as for other similar nouns in English, one word exists to describe the singular and the plural, for example sheep, or pollen. For those unfamiliar with this rule, one would never say “I saw six sheeps” or “the flower produced much pollens”. However, in the latter case, one would also not describe 2000 pollen grains as 200 pollen or 2000 pollens; rather, 2000 pollen grains would be used instead. One could thus argue that the plural of callus, when using “countable” forms, would require either calluses (UK or US), or calli (more classical Latin view). This is not a far-fetched concept to envisage. We may thus describe “much callus formed on leaf explants” when we are referring to multiple callus masses forming in different locations on a leaf explant or even on multiple leaf explants. In other words, in this case, the singular would be used to describe a singular or plural case. However, imagine we are referring to the

transfer of quantifiable pieces of callus, for example, to establish a fixed explant mass to initiate an experiment. It would certainly sound odd to describe it as “10 calluses/calli weighing 50 mg each were plated”. Thus, in this case, perhaps somewhat like pollen, a separate term altogether is required, and the correct expression would be “10 pieces of callus weighing 50 mg each were plated”. In this case, even though we are referring to multiple “calluses/calli”, the singular form of the word would be used. More conservative scientists would argue that the strict plural of the term callus should be used, i.e. calluses or calli. However, although I am a classic at heart, this could lead to errors, as indicated above, particularly among non-native English speakers. In essence, this would most likely not be problematic because any scientist reading a tissue culture manuscript would most likely understand the underlying intentional meaning, even if incorrectly stated. For example, even if a plant scientist were to describe as “10 calli weighing 50 mg each were plated”, or “10 calluses weighing 50 mg each were plated”, the best way to describe it would still be “10 pieces of callus weighing 50 mg each were plated”. This leads us to the question, if the US, UK or Latin plural forms of callus exist, i.e., calluses and calli, respectively, then why aren't they increasing in use. I believe that simply because they don't “sound right” within the context of plant tissue culture. As one Japanese scientist explained to me, the terms calli or calluses are difficult to listen to in an oral presentation, thus the standardization to callus for all forms would be a good way to standardize the use of the term. The above rule would hold valid even for terms related to the quantifiable callus pieces, for example “essential oils were extracted from 10 pieces of callus”.

When doing a Google-Scholar search, until 2011, the term “calli” was used in about 77,300 manuscripts while the term “calluses” was used in about 27,400 manuscripts (a 2.82:1 ratio). However, if we observe the literature from 2012 exclusively, “calli” was used in 3,700 papers while “calluses” was used in 2,220 manuscripts (i.e., a 1.67:1 ratio), suggesting that the term “calli” was on the decrease, or that “calluses” is on the increase. Interestingly, a search on Elsevier's sciencedirect.com reveals a completely opposite trend, i.e., that callus or calluses appears 26281 times while the term calli appears 5432 times, i.e., a roughly 4:84 ratio.

One more possibility may be that editors and reviewers of specific thematic journals may be encouraging their authors to describe the term in a uniform way, although this would require a more scrupulous and quantitative assessment.

Interestingly, in the Portuguese (Brazilian) literature,

there seems to be quite some confusion in the use, with many scientists using the Latin term calli for the plural, but other scientists using the Portuguese terms “calo” and “calos” to describe callus and calluses, respectively (quantifiable terms), although in Portuguese the term calo has a second meaning, organogenesis from plant tissues, somewhat diluting its impact of callus *sensu stricto*. Thus, a search on Scielo (<http://www.scielo.br>) reveals (until November, 2012) 46 papers with the term “callus”, 4 with “calli”, only one for “calluses”, but 21 for “calos”.

One could argue that ultimately this is a matter of style, or personal choice, and I could agree with that, provided that the correct term is employed. I am not in any way advocating the globalization of a single standardized term, just invoking thought regarding terms that appear to be inconsistently used throughout the plant tissue culture literature. It seems that it will be difficult to standardize the term because many plant scientists like to use the term in a very personalized way. So, several older generation professors like to use the term calli very strictly, what I call “old school” or “classical viewpoint” while many practical tissue culture scientists like to simplify this somewhat, so callus for singular and plural seems to be an attractive option for them. The trend in the mainstream literature appears to be moving towards the use of callus or calluses and away from calli. Independent of what people use, as long as we understand clearly what they want to say, we should not stifle choice, only encourage the use of the correct form.

ACKNOWLEDGEMENTS

I wish to thank the following individuals for their positive feedback and interesting discussion and feed-back among the approximately 50 plant tissue culture specialists contacted. Prof. Carlos Stortz (Departamento de Química Orgánica - CIHIDECAR, Universidad de Buenos Aires, Argentina), Dr. Yoichiro Hoshino (Field Science Center for Northern Biosphere, Hokkaido University, Japan), Prof. Veena Agrawal (Department of Botany, University of Delhi, India), Dr. Guohua Ma and Dr. Songjun Zeng (South China Botanical Gardens, Chinese Academy of Sciences, China), Dr. Budi Winarto (Indonesian Ornamental Crop Research Institute (IOCRI), Indonesia), Dr. Indra D. Bhatt (G.B. Pant Institute of Himalayan Environment and Development, India), Prof. Dietrich Knorr (Department of Food Biotechnology and Food Process Engineering, Berlin University of Technology, Germany), Dr. Marcela Gubišová (Centrum výskumu rastlinnej výroby Piešťany, The Slovak Republic), and Prof. Seiichi Fukai (Kagawa University, Japan).