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Can synthetic blood replacements be produced for vampires?

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Abstract
Consistently in media, vampires consume blood, and it is typically from humans. The reason for this varies depending on the lore of the specific media, and depending on what it is that the vampires specifically gain from the blood. Working under the assumption that vampires gain nutrients and molecules rather than life force from blood, this paper explores whether a blood product can be produced entirely synthetically, and whether it could perform the same functions as blood. Current research has developed synthetic serum and partially synthetic red blood cells, but not white blood cells.

Keywords: *Mythology; Biology; Haematology; Blood Substitutes; Vampires*

Vampires exist in multiple myths, legends, and fictional works, and one common feature that unites them is that they drink blood. However, the reasoning behind this varies depending on the media, with some drinking it in order to gain a life force, some drinking it for pleasure, and others for the nutrients. In order to design a replacement, the following assumptions will be made:

- Vampires drink blood to get nutrients and molecules and not to gain a "life force".
- Vampires require one pint of blood a week as a standard unit.
- Vampires are not sensitive to blood types and can drink any type.
- Only venous blood is considered.

This assumes that, even though they are dead, vampires drink blood to gain nutrients to perform the metabolic processes required for movement.

Human blood

Human blood contains three main components. The largest and least dense is the plasma, which is 55% of the total volume of blood [1, 2]. The plasma is mainly composed of water, 90%, with plasma proteins and electrolytes, hormones, and nutrients comprising the remaining 10% [1, 2]. The second and smallest layer, which comprises less than 1% of human blood, is made up of white blood cells and platelets, which are both involved in the immune response and blood clotting [1, 2]. The densest layer is made up of red blood cells, 45%, which contain haemoglobin and allow oxygen to be carried to tissues [1, 2]. In a blood substitute, in order to provide nutrients to the vampire, the plasma and the red blood cells would have to be replaced. It is not so crucial to replace the white blood cells as they are for immunological defence rather than nutrient transportation.

Synthetic plasma

Simulated bodily fluids have been explored previously, including synthetic plasma and serum; serum is blood plasma without the clotting factors [2]. In 2003, a research group explored simulated plasma replacements and concluded that a stable replacement could be produced using the components shown in figure 1 [3]. While the exact composition is not identical to blood plasma, it is stable and can be stored [3], allowing a vampire to stock up on a blood substitute rather than being forced to buy replacements every time they want or need sustenance.

One problem with this serum replacement, however, is that there are no plasma proteins present, as well as no hormones, or dissolved glucose [3]. One of the primary purposes of the plasma is to transport these around the body to regulate concentrations and execute specific functions [2]. If the vampire is undead, then several hormones will not be necessary and not need to be transported as they are not

Reagents[a]	Purity/%	m-SBF[e]
NaCl	>99.5	5.403 g
$NaHCO_3$	>99.5	0.504 g
Na_2CO_3	>99.5	0.426 g
KCl	>99.5	0.225 g
$K_2HPO_4 \cdot 3H_2O$	>99.0	0.230 g
$MgCl_2 \cdot 6H_2O$	>98.0	0.311 g
1.0 M—HCl	—	—
0.2 M—NaOH	—	100 mL[g]
HEPES[b]	>99.9	17.892 g[g]
$CaCl_2$	>95.0	0.293 g
Na_2SO_4	>99.0	0.072 g
TRIS[c]	>99.9	—
1.0 M—HCl	—	—
1.0 M—NaOH	—	≈ 15 mL

Figure 1 – Adapted from Table III [3]. The composition of the simulated blood plasma that showed the highest stability.

growing. Molecules like glucose can also dissolve into the synthetic plasma. Furthermore, as synthetic red blood cells will need to be added, other plasma proteins could be added in conjunction with this, like albumin [2], to make the serum replacement closer to reality.

Red blood cell replacements

The main part of erythrocytes to replicate is the haemoglobin, as this facilitates the transport of oxygen from the lungs to the tissues around the rest of the body. Assuming that it is the gas exchange that vampires require, synthetic oxygen carriers are crucial. One area that is being studied is artificial erythrocytes that can be transfused in the case of large blood loss and haemorrhagic shock [4]. A group produced haemoglobin vesicles by encapsulating isolated human haemoglobin in a phospholipid vesicle [4, 5], and a second produced large polymers of haemoglobin through beta-beta crosslinking bovine haemoglobin [6]. The advantage of the former method of encapsulation is that it shields the cells from the cytotoxic effects of haem and haem related products [7].

The haemoglobin vesicles have oxygen carrying capacity that is comparable to blood with the additional advantages that there are no blood type antigens, and no pathogens. They also have greater stability, which is more suitable for longer term storage [4] and would result in the vampire taking fewer trips to the synthetic blood bank. As a particle of blood and not a solute, there is no impact on the osmotic pressure from suspending the vesicles, although there is a requirement for a plasmid expander, like hydroxyethyl starch [4]. The viscosity of the haemoglobin vesicles is lower than that of blood due to the low lipid concentration and high encapsulation efficiency, but has higher viscosity compared to synthetic erythrocytes [5]. A problem that can occur from this is aggregation of haemoglobin vesicles which is induced by specific interactions with plasma components, and can lead to the decreased dispersibility of vesicles [5]. This is, however, reversible [5], and so could be mitigated in the vampires consuming it.

The haemoglobin vesicles are metabolised within seven days, with no irreversible damage to phagocytic organs, the lungs, liver, or kidneys [8]. The iron was excreted and recycled successfully, inducing no cytotoxic effects that free haem normally induces [8]. This would allow the vampires to metabolise it as they would blood. The encapsulation suppresses renal excretion, and leads to better haemodynamics and longer circulation time [8], which provides a better shelf life. Furthermore, the mean arterial pressure, arterial blood gas analysis, and the renal cortical tissue oxygen tension with the haemoglobin vesicles have no significant difference compared to red blood cells [9].

The main problem with the haemoglobin vesicles is that the haemoglobin itself thus far has originated from mammalian origins [4, 5, 6] and is therefore not entirely synthetic. One potential experiment that could be trialled to source haemoglobin would be to insert the gene for the alpha and beta chains into a bacterium like *E. coli* to produce the haemoglobin chains, which can then be encapsulated. This has not been explored yet, but finding another source to produce the haemoglobin would be crucial in order to classify it as “vegan” for the vampires.

Conclusion

Presently, entirely synthetic blood does not exist for vampires. Replacements for the two major transporting components of blood can be produced, but the replacement for erythrocytes relies upon haemoglobin, which presently is obtained from mammalian sources. However, if the haemoglobin could be synthesised and obtained through another mechanism for encapsulation, a synthetic blood product could be produced which would result in vampires no longer needing to feed on humans. The ideal solution currently would be using the synthetic serum described above, with artificial haemoglobin carriers. The synthetic properties would provide a wide range of applications in trauma and emergency medicine, acting beyond fantasy.

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